

CONTRACT DOCUMENTS

Provo River Water Treatment Plant

PROVOEN202323202

June 2023

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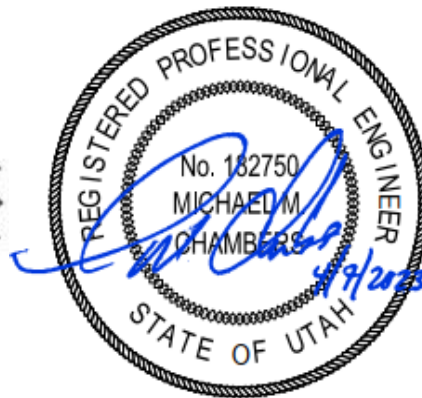
SECTION 00 01 01

TITLE PAGE

CONSTRUCTION OF

Provo River Water Treatment Plant

BID NO. PROVOEN202323202



CONTRACT DOCUMENTS

Prepared By

**Hansen, Allen & Luce, Inc.
859 West South Jordan Parkway, Suite 200
South Jordan, Utah 84095
(801) 566-5599**

**AECOM
756 East Winchester Street
Salt Lake City, Utah 84107
(801) 904-4000**

Prepared For

**Provo City Water Resources
1377 South 350 East
Provo, Utah 84606
(801) 852-6740**

Bids will be received and deposited at the office of the Provo City Water Resources, located at the above address on the first floor, until 2:00 p.m., August 31, 2023.

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UDOT 2022 STANDARD SPECIFICATIONS

The following UDOT 2022 Standard Specifications are incorporated into these Contract Documents specifically, and Sections referenced therein by extension. The latest UDOT Standard Specifications may be found at: <https://udot.utah.gov/connect/business/standards/>

02701	Pavement Smoothness
02705	Concrete and Asphalt Cutting
02721	Untreated Base Course (UTBC)
02735	Micro-Surfacing
02741	Hot Mix Asphalt
02744	Stone Matrix Asphalt
02745	Asphalt Material
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02748	Prime Coat/Tack Coat

ATTACHMENT A – GEOTECHNICAL REPORT

PROJECT PLANS

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INVITATION TO BID

PART 1 - GENERAL

1.01 CONSTRUCTION CONTRACT

- A. Bidders are invited to bid on the Construction Contract known as Provo River Water Treatment Plant Project.
- B. The location of the work is: approximately 2100 North Freedom Blvd (200 West), Provo Utah.
- C. The Work generally includes, but is not limited to, the following: Construction of a 30 MGD ultrafiltration membrane drinking water treatment plant including, the main Water Treatment Plant Facility with Administration Building, 2 MG Clearwell with drain vault and overflow structure, High Service Pump Station, 36-inch diameter Transmission Pipeline with valve vault, 42-inch diameter Mill Race Pipeline with diversion box, electrical and controls including three (3) 1,000 kW natural gas generators, security cameras, fencing, and site restoration, paving, and landscaping.
- D. Questions regarding this project should be addressed in writing to Shane Jones, P.E., located at Provo City Water Resources, 1377 South 350 East, Provo, Utah 84606, (801) 852-6773 or sjones@provo.utah.gov or to Michael Chambers, P.E. (Hansen, Allen & Luce), located at 6771 South 900 East, South Jordan, Utah 84095, (801) 803-1828 or mchambers@halengineers.com.
- E. Only Bidders who have been pre-qualified by the Provo City Water Resources (Owner) may submit bids on this project.

1.02 BID LOCATION AND OPENING

- A. Sealed bids will be received until 2:00 p.m., August 31, 2023 at the Provo City Water Resources Office, 1377 South 350 East, Provo, Utah 84606, at which time and place all bids will be publicly opened and read aloud. Bids received after 2:00 p.m., as conclusively established by the clock at the Bid opening location, will not be accepted.
- B. On the outside of the envelope, the bidder shall indicate the Construction Contract title, the name and address of the Bidder, and the date and time of Bid opening and the Bidder's return mailing address.

1.03 BID BONDS

- A. A Bid Bond in the amount of 5 percent of the Bid must accompany each Bid in accordance with the Instructions to Bidders. The Bid Bond will be returned to each unsuccessful Bidder after tabulation and award of the Construction Contract.

1.04 BASIS OF BIDS

- A. Bids shall be on a unit price basis. Unsealed or segregated Bids will not be accepted.

1.05 CONTRACT TIME

- A. The Work will be Substantially Complete by **December 31, 2025**.

1.06 EXAMINATION AND PROCUREMENT OF DOCUMENTS

- A. Complete sets of Contract Documents may be examined and obtained online at SciQuest (www.purchasing.utah.gov) or from the Owner at 1377 South 350 East Provo, Utah after **June 28, 2023**. The cost of the contract documents, when obtained from the Owner, is \$30.00 and is non-refundable.

1.07 PRE-BID CONFERENCE

- A. Prospective Bidders are required to attend a Pre-Bid Conference which will be held at the Provo City Public Works Office located at 1377 South 350 East, Provo, Utah 84606 at **9:00 a.m. on July 19, 2023**. The object of the conference is to acquaint Bidders with the site conditions, specifications, and to answer any questions which Bidders may have concerning the project. The pre-Bid conference is mandatory. Representatives of Owner and Engineer will be present to discuss the Project. Engineer will transmit to all prospective Bidders of record such Addenda as Engineer considers necessary in response to questions arising at the conference. Oral statements may not be relied upon and will not be binding or legally effective.

1.08 RIGHT TO REJECT BIDS

- A. The Owner reserves the right to reject any or all bids or to waive any informality or technicality in any bid if deemed to be in the best interest of the Owner.

1.09 GOVERNING LAWS AND REGULATIONS

- A. This is a federally funded project. All bidders are required to make the six good faith efforts to assure compliance with the State's "fair share goals" and are required to comply with EEO regulations.
- B. Bidders on this Work will be subject to the applicable provisions of all federal rules, laws and regulations or orders.
- C. Bidder must provide proof that he has completed the registration process in an approved immigration status verification system and is in full compliance with the immigration status verification program as well as all requirements of Utah Code Section 63G-12-302.
- D. Bidder will also be required to provide similar proof of compliance for any subcontractor who works under the terms of the Contract Documents.

- E. The Owner reserves the right to reject any or all bids; or to accept or reject the whole or any part of any bid; or to waive any informality or technicality in any bid in the best interest of the Owner. Only bids giving a firm quotation properly signed will be accepted.

END OF SECTION

SECTION 00 21 13

INSTRUCTIONS TO BIDDERS

PART 1 - GENERAL

1.01 DEFINED TERMS

- A. Terms used in the Bid Documents that are defined in Article 1.1 of the General Conditions will have the meanings indicated in the General Conditions.
- B. General Conditions: as published in Document 00 72 00 in the Manual of Standard Specifications by the Utah Chapter of the American Public Works Association.

1.02 COPIES OF BID DOCUMENTS

- A. Bidders must use complete sets of Bid Documents in preparing Bids. Owner and Engineer assume no responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bid Documents.
- B. Bid Documents are made available to bidders only for the purpose of obtaining Bids on the Work. No license or grant for any other use is given.
- C. Bidding Document copyrights shall remain with the Owner.
- D. Only provisions that are referenced in the document of the current edition of the Manual of Standard Specifications and Manual of Standard Plans published by the Utah Chapter of the American Public Works Association that are applicable to the Work are hereby made a part of the Contract Documents by reference. The publications may be purchased separately from the LTAP Center, Utah State University 8205 Old Main Hill, Logan UT 84322-8205.
- E. For work within UDOT's right of way, all provisions of the State of Utah Standard Specifications and Standard Drawings for Road and Bridge Construction, U.S. Standard Units (Inch Pound Units), Edition 2012, as well as all other specified changes that are applicable to the Work are hereby made part of the Contract Documents by reference. The documents may be obtained separately from UDOT's website, www.udot.utah.gov.

1.03 PRE-BID COMMUNICATION

- A. The Owner shall not be bound by any statements, representations, conclusions, or assumptions made by any party, whether oral or written, except for written statements that are issued in an Addendum by the Engineer to all prospective bidders.

1.04 PHYSICAL CONDITIONS

- A. In General: Prior to submitting a Bid, each Bidder is responsible to review all available explorations, tests and data concerning surface conditions, subsurface conditions and

Underground Facilities at or contiguous to the site, or otherwise, which may affect cost, progress, performance or furnishing of the Work in accordance with the time, price and other terms and conditions of the Contract Documents.

- B. **Underground Facilities:** Information and data indicated in the Contract Documents regarding Underground Facilities at or contiguous to the site is based upon information and data furnished to Owner and Engineer by owners of such Underground Facilities. The Owner does not assume responsibility for the accuracy or completeness thereof other than as provided in paragraph 4.3A.2 of the General Conditions or unless expressly provided in the Modifications to General Conditions (Document 00 73 00).
- C. **Additional Explorations and Tests:** If feasible as determined by Owner, the Owner will provide each Bidder access to the site to conduct any explorations and tests as each Bidder deems necessary for submission of a Bid. Bidder shall obtain permits, fill all holes, clean up and restore the site to its former condition upon completion of such explorations. by requesting such an exploration or test, Bidder agrees to release, indemnify, defend, and save the Owner harmless from all costs damages and liabilities an any kind whatsoever, including reasonable attorneys' fees, that may arise in connection with or as a result of the performance of such explorations or tests.

1.05 COMPENSATION AND QUANTITIES

- A. **In General:** The bid price for any lump sum or unit price contract includes all labor, materials, and incidental work to fully complete the Work in a satisfactory manner under the terms of the Contract Documents. Bidders are responsible to inform themselves of the character of the Work to be performed.
- B. **Lump Sum Work:** If the Work is to be paid for on a lump sum basis, the lump sum will be the only sum paid.
- C. **Unit Price Work:** If any portion of the Work is to be paid for on a unit price basis, payment will cover only work actually performed and materials actually supplied at the unit prices bid and on the terms set forth in the Contract Documents, irrespective of any quantity approximations in the Bid Documents. Any quantity approximations in the Bid Documents are stated as a basis for determining bids, and the do not fix the amount of Work to be done or materials to be furnished. Stated quantities are estimates for the purpose of doing the class of work required. Actual quantities will vary. The OWNER may deviate in either direction from any indicated quantities. The Bidder shall have no claim for any variation in quantity, except to the extent permitted in the General Conditions.

1.06 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

- A. **In General:** The Owner shall not be bound by any statements, representations, conclusions, or assumptions made by any party, whether oral or written, except for written statements that are in the Contract Documents or in an Addendum.

- B. Access: The Contract Documents designate the site for performance of the Work. Bidder is responsible to investigate the site and understand all access requirements. All additional off-site lands and access thereto required for temporary construction facilities or storage of materials and equipment are to be provided by Bidder.
- C. Contract Documents: The submission of a Bid will constitute an incontrovertible representation by Bidder that Bidder has complied with every requirement of this Article 1.4; that without exception the Bid is premised upon performing and furnishing the Work required by the Contract Documents; and that the Contract Documents are sufficient in scope and detail to indicate and convey understanding of all terms and conditions for performance and furnishing of the Work.
- D. Bidder's Obligations: In addition to Bidder's other responsibilities and obligations in connection with submitting a Bid, it is the responsibility of the Bidder before submitting a Bid, to:
1. Examine the Contract Documents thoroughly;
 2. Visit the site to become familiar with local conditions that may affect cost, progress, performance or furnishing of the Work;
 3. Investigate all applicable construction and labor conditions, quantities, and the character of the Work as they affect cost, progress, performance, or furnishing of the Work;
 4. Consider federal, state and local Laws and Regulations that may affect cost, progress, performance or furnishing of the Work;
 5. Study and carefully correlate Bidder's observations with the Contract Documents;
 6. Review all available explorations and data concerning surface and subsurface conditions as set forth in Section 1.4 above; and
 7. Identify and notify ENGINEER in writing in the manner set forth in article 2.1 below of all specific conflicts, omissions, errors, or discrepancies in the Contract Documents, or if Bidder doubts their meanings.

The failure or omission of any Bidder to take any of the foregoing actions shall not in any way relieve Bidder of its Bid, or its obligation to furnish all material, equipment, labor and services necessary to carry out the provisions of the Contract Documents and to complete the contemplated Work for the consideration set forth in its Bid. Submission of a Bid shall constitute prima facie evidence of compliance with these instructions.

- E. Deviations from the Terms of the Contract Documents: Owner will not accept any deviations whatsoever from the printed terms of the Agreement and the Contract Documents, except by Addendum or Change Order.

1.07 EFFECT OF SUBMITTING BID.

- A. Bidders are responsible to carefully examine the Contract Documents, visit the site, and fully inform themselves so as to include in the Bid a sum to cover the cost of all items. Bidder's failure or omission to receive or examine any form, instrument, addendum or other document, visit the site and become acquainted with existing conditions, or attend any pre-Bid Conference, shall in no way relieve Bidder from any obligations with respect to Bidder's Bid or the Construction Contract.
- B. By submitting a Bid, Bidder represents that Bidder has complied with all requirements of the Bid Documents; that the Bid is premised on properly performing and furnishing the Work required by the Contract Documents within the times specified; that the Bidder is informed of the conditions to be encountered and the character, quality and quantities of the Work; and that the Bidder believes the Contract Documents are sufficient in scope and detail to indicate and convey understanding of all terms and conditions for performance and furnishing of the Work.
- C. Submission of a Bid constitutes a promise that the Bidder will enter the Contract in the form presented in the Contract Documents. Bidders should carefully examine all Contract Documents, including the required Bonds and insurance to be provided by the Bidder.
 - 1. The Performance Bond is a guarantee of faithful performance of the requirements of the Contract Documents, including all applicable warranties. The Payment Bond is a guarantee of payment of all labor, materials, or supplies used directly or indirectly in the prosecution of the Work provided in the Construction Documents.
 - 2. The sum of the Performance Bond and the Payment Bond shall be increased or decreased during the course of the Work in the event that Contract Modifications, Change Orders or Addenda increase or decrease the total contract price. The sum of each bond shall be in an amount equal to the completed contract price at the completion of the Work.
 - 3. OWNER does not provide any release of Performance Bonds or Payment Bonds. The bonds are in effect throughout all periods during which a suit may be brought under the provisions of applicable law.
- D. By submitting a Bid, Bidder represents that the matters stated therein are true and correct.

PART 2 - BIDDING PROCEDURES

2.01 INTERPRETATIONS AND ADDENDA

- A. All requests for interpretation of the Contract Documents shall be made in writing and delivered to the Engineer no later than seven (7) calendar days prior to opening of Bids. In the Engineer's discretion, Engineer will send the written interpretation to all persons receiving a set of Bid Documents in the form of an Addendum. If the Engineer does not

respond to a Bidder's request for interpretation the Bidder shall comply with the intent and terms of the Contract Documents.

- B. No oral interpretations shall be made to any Bidder. The Owner shall not be responsible for or bound by any statements, interpretations, explanations, representations, conclusions or assumptions made by any party, whether oral or written, except for written statements that are issued in an Addendum by the Engineer to all prospective bidders.
- C. Each statement made in an Addendum is part of the Contract Documents at the location designated in the Addendum. A statement issued in an Addendum shall have the effect of modifying a portion of the Bid Documents when the statement in the Addendum specifies a particular section, paragraph or text and states that it is to be so modified. Only the specified section, paragraph or text shall be so modified, and all other portions of the Bid Documents shall remain in effect.
- D. Bidders shall sign to acknowledge their receipt of all Addenda issued. Bidders shall also acknowledge receipt of all Addenda in the space provided in the Bid.
- E. Except to postpone the Bid opening, no Addenda shall be issued within 48 hours of the Bid opening.

2.02 EQUIPMENT AND MATERIAL OPTIONS PRIOR TO BID OPENING

- A. The Contract, if awarded, will be on the basis of materials and equipment described in the Drawings or specified in the Specifications without consideration of possible substitute or "or equal" items. Whenever it is indicated in the Drawings or specified in the Specifications that a substitute or "or approved equal" item of material or equipment may be furnished or used by Contractor if acceptable to Engineer, application for such acceptance will not be considered by Engineer until after the Effective Date of the Agreement. The procedure for submission of any such application by Contractor and consideration by Engineer is set forth in the General Conditions and may be supplemented in the General Requirements.

2.03 BID SECURITIES

- A. Amount of Bid Security: A Bid Security must accompany each Bid. The total amount of the Bid on which Bid security is to be based shall be the sum of all items of the Bid constituting the maximum amount of the possible award to the Bidder. The Bid Bond amount must equal at least five (5) percent of the total amount of the Bid.
- B. Form of Bid Security: The Bid Security may be in the form of a certified check, cashier's check, cash, or Bid Bond. No other form of Bid Security will be accepted. A Bid Bond must be issued by a licensed Utah agency on behalf of a surety company licensed to do business in the State of Utah. A cashier's check must be drawn on a bank doing business in the State of Utah and made payable to OWNER. If a cashier's check is used in lieu of a Bid Bond, or if the Bid Bond does not specifically so provide, a certificate from an approved surety company guaranteeing execution of performance and payment bonds in the full amount of the bid must accompany the bid.

- C. Purpose of Submission: By submitting a Bid Bond Bidder assures Owner it will take all steps necessary to properly execute the Contract Documents.
- D. Return of Bid Security: Owner will return Bid securities to Bidder within 7 days after award of the Construction Contract. Bid Bonds and cashier's checks of all Bidders will be held until the Construction Contract is awarded or all bids have been rejected. The liability of Owner in regards to the checks shall be limited only to the return of the checks.
- E. Default: In the event of failure or refusal of the Bidder to enter into the Construction Contract and the delivery to the Owner a Performance Bond, Payment Bond and any other Bonds or documents required by the Contract Documents after Notice of Intent to Award by the Owner, the Bidder forfeits the sum of the Bid Bond or cashier's check as liquidated damages to the Owner.

2.04 COMPLETING BID DOCUMENTS

- A. The General Conditions identify all forms comprising the Bid Documents. Additional copies may be obtained from the ENGINEER. The Bidder shall make no stipulations or alterations on the Bid forms. The Bidder must use and execute only the Bid form and Bid Schedules bound in the Contract Documents. , Bidder shall complete and submit all forms and documents listed in paragraph 2.06.C below.
- B. The Bidder must fill in all items in the Bid form in ink or by typewriter. If applicable, furnish both the unit and total costs for each item. The total Bid price is the full price for the performance of all Work under the Contract Documents. Bidder shall initial in ink any corrections, interlineations, alterations, or erasures made by the Bidder on Bidder's entries in the Bid Documents.
- C. Any work or material which is specified in the Contract Documents or which is necessary because of the nature of the Work, but which is not listed separately in the Bid Schedule shall not be measured or paid for separately. The cost of such work or material shall be considered as included in the Contract Price.
- D. Bids by corporations must be executed in the corporate name by a corporate officer authorized to sign, and must be properly attested to as an official act of the corporation. At the OWNER's request, authority to sign shall be submitted.
- E. Bids by partnerships or joint ventures must be executed in the partnership or joint venture name and signed by a partner or joint venture whose title and official address must be shown. If a partnership or joint venture is the low bidder, the partnership or joint venture must also submit evidence to the OWNER of the responsibility of the partnership or joint venture as a bidder in the manner directed by the ENGINEER.
- F. Where the Bidder is wholly owned subsidiary of another company, the Bid must so state, and the owner or parent corporation also must agree to sign and be bound with the Bidder.
- G. All names must be typed or printed under or near the signature. Signatures shall be in longhand.

- H. The Bid shall contain an acknowledgment of receipt of all Addenda. The Addenda numbers must be filled in on the Bid form.
- I. The Bidder's address, telephone number, email address, and facsimile number for communications regarding the Bid must be shown on the first page of the Bid form.
- J. The divisions and sections of the specifications, and the identifications of any Drawings, shall not control Bidder in dividing the Work among subcontractors or suppliers, or delineating the Work to be performed by any specific trade.
- K. The base Bid and alternates shall include all Work required to be performed by the Contract Documents.

2.05 CONFLICT OF INTEREST, SUBCONTRACTORS

- A. Conflict of interest pertaining to Subcontractors is described in paragraph 6.5H of the General Conditions (Document 00 72 00).
- B. Bidder shall not subcontract more than 75 percent of the dollar value of the total contemplated Work (exclusive of the supply of materials and equipment to be incorporated in the Work) without OWNER's prior written approval.

2.06 SUBMISSION OF BIDS

- A. Bids shall be submitted at the time and place indicated in the Invitation to Bid and should be enclosed in an opaque sealed envelope, marked with the Construction Contract name and number, the name and address of the Bidder, and the date and the opening time for Bids. If the Bid is sent through the mail or other delivery system the sealed envelope should be enclosed in a separate envelope with the notation "BID ENCLOSED" on the face of it. It is the sole responsibility of the Bidder to deliver the Bid before the scheduled time.
- B. Bidder will make no recapitulations, stipulations, alterations, alternate submissions, or modifications in any manner to any of the Contract Documents.
- C. All bidders shall include the following Bid Form documents with required signatures and notarized when designated:
 - 1. Bid Form (Document 00 41 00)
 - 2. Bid Schedule (Document 00 43 00)
 - 3. Non-Collusion Affidavit of Prime Bidder (Document 00 45 38)
 - 4. Bid Bond (Document 00 42 00)
Failure to include any of these documents will result in Bid being considered non-responsive and may be disqualified.

- D. Alternate bids, other than those called for in the Bid form, will not be considered.
- E. No oral, telegraphic, telephonic, facsimile, or modified bids will be considered.

2.07 MODIFICATION AND WITHDRAWAL OF BIDS

- A. At any time prior to the opening of Bids, Bids may be modified or withdrawn if a written notice of modification or withdrawal is signed by Bidder and delivered to the place where Bids are to be submitted. Bid Security will be returned upon proper withdrawal of a Bid prior to the time for Bid opening.
- B. Within 24 hours after Bids are opened, any Bidder may file written notice with Owner that there was a substantial mistake made in the preparation of its Bid. Bidder must thereafter promptly demonstrate Bidder's mistake. The Owner has sole discretion to determine whether to permit any modification or withdrawal or the return of any Bid Security.
- C. When it appears a mistake has been made, or when the Owner desires an assurance of any matter, the Owner may request a Bidder to confirm the Bid in writing.

2.08 OPENING OF BIDS

- A. Bids will be opened and read aloud publicly unless obviously non-responsive. An abstract of the amounts of the base schedule of prices and any alternate schedules will be made available for review after the opening of Bids.
- B. Any Bids received after the time specified in the Invitation to Bid will be returned unopened.

2.09 BIDS SUBJECT TO ACCEPTANCE FOR 60 DAYS

- A. All bids remain subject to acceptance for 60 days after the day of the Bid opening. Owner may, in its sole discretion, release any Bid and return the Bid security prior to that date.

PART 3 - EVALUATION AND AWARD

3.01 SUBMITTALS REQUIRED FOR EVALUATION

- A. After Bid opening, the Bidder, whose Bid is under consideration, must submit the following at the times specified:
 - 1. Bidder Status Form: Document 00 43 38. The Bidder shall submit this report form within 24 hours of Engineer's request.
 - 2. Proposed Subcontractor Form: Document 00 43 36. The Bidder shall submit this report form within 24 hours of Engineer's request.

3.02 EVALUATION OF BIDS

- A. Owner reserves the right: to reject any and all Bids or any part thereof; to waive any informalities in the Bid Schedule and elsewhere; to negotiate and agree to contract terms with the successful Bidder; to disregard non-conforming, non-responsive, unbalanced or conditional Bids; and to withhold the award for any reason deemed in the best interests of the Owner.
- B. Owner reserves the right to reject any Bid if Owner believes that it would not be in the best interest of the Project or the Owner. Without limitation, such rejection may be because the Bid is not responsive, or the Bidder is unqualified or of doubtful ability or the Bid or Bidder fails to meet any other pertinent standard or criteria established by Owner.
- C. If the Owner intends to make an award to a Bidder, a Notice of Intent to Award will be issued within 30 days of bid opening.
- D. Owner may consider all information which Owner believes is relevant when evaluating a Bid, including, without limitation:
 - 1. The qualifications and experience of the Bidder and of the Subcontractors, Suppliers, and other persons and organizations proposed (whether or not the Bid otherwise complies with the prescribed requirements).
 - 2. Such alternates, unit prices and other data, as may be requested in the Bid Form, Bid Schedule, or written requests issued prior to Owner's Notice of Intent to Award the Construction Contract.
 - 3. Operating costs, maintenance requirements, performance data, and guarantees of ability to provide the required materials and equipment.
 - 4. Corporate organization and capacity for any party.
 - 5. Ability to perform and complete the Work in the manner and within the time specified.
 - 6. Pending litigation.
 - 7. The amount of the Bid.
 - 8. Proper licensing to do the Work in compliance with licensing laws of the State of Utah for contractors and subcontractors.
 - 9. All other relevant matters, consistent with Owner's procurement code and administrative rules, Owner's ordinances and program policies.
- E. If the Construction Contract is to be awarded, it will be awarded to the most responsive, qualified, and responsible Bidder as determined by the Owner. Alternates, as identified on the Bid Form, may be accepted depending upon availability of Owner's funds and as

determined by the Owner. Accepted alternates will be considered in determining the most responsive, qualified, and responsible Bidder.

F. Bid Schedules will be evaluated as follows:

1. Discrepancies in the multiplication of quantities of Work items and unit prices will be resolved in favor of the unit prices. Owner may correct Bid Schedule calculation errors accordingly.
2. Prices written out in words shall govern over prices written out in numbers.
3. Discrepancies between the indicated sum of any column of figures and the correct sum thereof will be resolved in favor of the correct sum.
4. Bids shall not contain any recapitulations of or changes in the work to be done.

G. The Owner, in the Owner's sole discretion, shall make determinations as to disqualification of Bidders or rejection of Bids. Such matters may include, without limitation, submission of more than one Bid by the Bidder (whether under the same or different names); evidence of collusion among Bidders; other commitments of Bidder which, in the Owner's sole judgment, might hinder the Work; previous defaults, Bid irregularities when not waived in the best interests of the Owner, delays or poor performance by Bidder on any project; official action against Bidder; and any other cause which, in the Owner's sole discretion and judgment, is sufficient to justify disqualification of a Bidder or rejection of a Bid.

3.03 ADJUSTMENTS TO THE COST OF THE WORK AFTER OPENING OF BIDS

- A. The Contract Price identified in the Agreement represents the cost of the work which is to be paid by the Owner to the Contractor.
- B. Adjustments to the Contract Price which are agreed to between the Owner and the successful Bidder shall be affected by signing an Agreement Supplement.

3.04 SUBSTITUTIONS

- A. The Construction Contract, if awarded, will be on the basis of materials and equipment described in the Drawings, Specifications and any Addenda.
- B. After the Effective Date of the Construction Contract, the procedure for submitting an application for substitution is set forth in Article 6.4 of the General Conditions.

3.05 SUBMITTALS REQUIRED FOR AWARD OF CONTRACT

In order to execute the contract, the following documents shall be submitted to Owner within seven (7) calendar days of the receipt of the NOTICE OF INTENT TO AWARD.

- A. Performance Bond: The Owner's requirements as to performance bonds are as set forth in the Modifications to General Conditions (Document 00 73 03). Specific requirements are set forth in the Performance Bond (Document 00 61 13).
 - 1. The form of the Bond should be carefully examined by the Bidder.
 - 2. When the successful Bidder delivers the executed Construction Contract to Owner, it must be accompanied by the required Performance and Payment Bonds.
- B. Payment Bond: The Owner's requirements as to payment bonds are as set forth in the Modifications to General Conditions (Document 00 73 03). Specific requirements are set forth in the Payment Bond (Document 00 61 14).
 - 1. The form of the Bond should be carefully examined by the Bidder.
 - 2. When the successful Bidder delivers the executed Construction Contract to Owner, it must be accompanied by the required Performance and Payment Bonds.
- C. Certificate of Insurance: The Owner's requirements as to insurance are as set forth in the Modifications to General Conditions (Document 00 73 03).
- D. Status Verification System Affidavit: The Owner's requirements as to immigration status verification are set forth in the Modifications to General Conditions (Document 00 73 03). Specific requirements are set forth in the Status Verification System Affidavit (Document 00 45 37).
- E. Other Information: When a determination has been made to award the Construction Contract, Bidder is required, prior to the award or after the award, or both, to furnish such other information as the Engineer requests.

3.06 SIGNING OF AGREEMENT

- A. Within ten (10) calendar days after Owner issues Notice of Intent to Award the Construction Contract to the successful Bidder, the Bidder shall pick up, sign and return to Owner, the required number of copies of the Agreement (Document 00 52 00), bonds, insurance, and Status Verification System Affidavit: A minimum of six (6) originals will be signed and returned to the Owner. One executed original will be returned to the Bidder. Bidder shall comply with all execution requirements.
- B. All of Bidder's executions and submittals must be delivered to the Owner before Owner will execute the Construction Contract. The Construction Contract will not be deemed awarded and shall not be binding on the Owner until it has been approved and executed by the Owner, and a fully executed copy is formally delivered to the Contractor. The Owner reserves the right to rescind its Notice of Intent to Award without liability, except for the return of Bidder's Bid Security, at any time before the Construction Contract has been fully executed by all parties and delivered to the Contractor.

- C. Transfers, delegations or assignments of interests in the Contract Documents are prohibited, unless prior written authorization is received from the Owner.
- D. At the time of Bidding, and the signing of the Agreement, and at all times during the Work, Bidder shall be properly licensed to do the Work and shall be in compliance with the license laws of the State of Utah, Provo City and Utah County. The Bidder shall also require all Subcontractors to do the same.
- E. If a Bidder fails to fully and properly execute the Construction Contract and provide all submittals required therewith within ten (10) calendar days after the date of the Notice of Intent to Award, the Owner may elect to rescind the Notice of Intent to Award, and the Owner shall be entitled to the full amount of Bidder's Bid Security, not as a penalty, but in liquidation of and compensation for damages sustained. In the Owner's sole discretion, a Notice of Intent to Award may then be provided to another bidder whose Bid is most advantageous to the Owner, price and other factors considered.

END OF SECTION

SECTION 00 31 32
GEOTECHNICAL DATA

PART 1 - GENERAL

1.01 REPORTS OF EXPLORATIONS AND TESTS

- A. In preparing the Drawings and Specifications, Engineer has relied upon the following geotechnical reports of explorations and tests of subsurface conditions at or contiguous to the Work site.
 - 1. Report dated 9 April 2021 prepared by AGECE, Inc. entitled: Geotechnical Study - Provo River Diversion Structure – 260 West 2230 North – Provo, Utah consisting of 38 pages.
- B. Accuracy: For the purposes of bidding or construction, the Bidder may rely upon the accuracy of the geotechnical data at the locations where the data was obtained and to the depths indicated, but not upon any other information, interpretations or opinions contained in the geotechnical data itemized above or for the completeness thereof expressed or implied.
- C. Geotechnical Data Not a Part of the Contract Documents: Geotechnical data itemized above are not a part of the Contract Documents, but the technical data contained therein upon which Bidder is entitled to rely as provided in Article 4.02 of the General Conditions (Document 00 72 00) are incorporated by reference.

1.02 DRAWINGS OF SURFACE AND SUBSURFACE STRUCTURES

- A. In the preparation of Drawings and Specifications, Engineer has relied upon the following drawings of physical conditions in or relating to existing surface and subsurface structures (except Underground Facilities) which are at or contiguous to the Work site.
 - 1. None
- B. Drawings Not a Part of the Contract Documents: Drawings itemized above are not a part of the Contract Documents. Location of the surface and subsurface structures and utilities are further described in Article 4.3 of the General Conditions (Document 00 72 00).

1.03 EXAMINATION OF DATA

- A. Copies of geotechnical data and drawings of surface structures and subsurface structures may be examined during regular business hours at Provo City Water Resources, 1377 South 350 East, Provo, Utah.

END OF SECTION

SECTION 00 39 12

NOTICE OF INTENT TO AWARD

To: _____

PROJECT DESCRIPTION: **Work consists of the construction of a 30 MGD ultrafiltration membrane drinking water treatment plant including, but not limited to, the main Water Treatment Plant Facility with Administration Building, 2 MG Clearwell with drain vault and overflow structure, High Service Pump Station, 36-inch diameter Transmission Pipeline with valve vault, 42-inch diameter Mill Race Pipeline with diversion box, electrical and controls including three (3) 1,000 kW natural gas generators, security cameras, fencing, and site restoration, paving, and landscaping.**

The Owner has considered the BID submitted by you for the above described WORK in response to its Advertisement for Bids called: **Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202**

You are hereby notified that your BID has been accepted for items in the amount of:

\$ _____.

In order to execute the contract, all documents as specified in Document 00 21 13 – 3.6 shall be submitted to the Owner within seven (7) calendar days of the receipt of this NOTICE OF INTENT TO AWARD.

You are required to return an acknowledged copy of this NOTICE OF INTENT TO AWARD to the Owner. Dated this ____ day of _____, _____.

PROVO CITY CORPORATION

Owner

By _____

Shane C. Jones, P.E.

Title _____

Project Engineer

ACCEPTANCE OF NOTICE

Receipt of the above NOTICE OF INTENT TO AWARD is hereby acknowledged

By _____

this the ____ day of _____, _____

By _____

Title _____

SECTION 00 39 13

NOTICE TO PROCEED

To: _____

Date: _____

PROJECT DESCRIPTION: **Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202.**

You are hereby notified to commence work in accordance with the Agreement dated _____ on or before _____ and you are to substantially complete the WORK on or before **December 31, 2025**. The date of completion of all WORK is therefore **March 2, 2026**.

PROVO CITY CORPORATION

Owner

By _____

Shane Jones, P.E.

Title _____

City Project Manager

ACCEPTANCE OF NOTICE

Receipt of the above NOTICE TO PROCEED is hereby acknowledged

By _____

this the _____ day of _____, _____

By _____

Title _____

END OF SECTION

SECTION 00 41 00

BID FORM

PART 1 - GENERAL

1.01 BID PROPOSAL

- A. After having personally and carefully examined all conditions surrounding the Work and the Contract Documents, the undersigned proposes to furnish all labor, materials, equipment, tools and machinery and to furnish and deliver all materials not specifically mentioned as being furnished by the OWNER, which is required in and about the construction of the Construction Contract known as **Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202**.
- B. The undersigned proposes to complete the Work for the price or prices listed in the Bid Schedule (Document 00 43 00) and understands that quantities for Unit Price Work are not guaranteed.
- C. The undersigned proposes to furnish bonds with the Contract, signed by a surety company satisfactory to the OWNER, in an amount equal to the Contract amount to ensure compliance with all requirements of the Contract Documents.
- D. The undersigned encloses a certified check, cashier's check, cash, or a Bid Bond for _____ Dollars (\$_____) which is five (5) percent of the Bid amount payable to the Owner, as a guarantee of good faith, and which it is agreed will be forfeited to the Owner as liquidated damages in the event of the failure of the undersigned to enter into a contract and furnish satisfactory bonds to the Owner.
- E. The undersigned proposes to execute the attached contract within ten (10) days after the Notice of Intention to Award, and to begin work within ten (10) days after being notified to do so by the Owner.
- F. The undersigned agrees the Bid is genuine. The Bid is not made in the interest of or on behalf of any undisclosed person, firm or corporation. The undersigned agrees that they have not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid: that they have not solicited or induced any person, firm or corporation to refrain from bidding: and that they have not sought by collusion to obtain for itself any other advantage over any separate Bidder or over Owner.
- G. If Owner finds it necessary to further define the Work, Contract Price, Contract Time or some other portion of the Construction Contract, after Bid opening, the Bidder promises to execute an Agreement Supplement prior to or concurrent with the execution of the Agreement, if the Agreement Supplement is acceptable to the Bidder.

- H. It is understood that the Owner has the right to reject this proposal or to accept it at the prices listed in the Bid Schedule.

PART 2 - EXECUTION

2.01 BIDDER

- A. The Bidder is as follows

Name: _____

Address: _____

Telephone number: _____

Facsimile number: _____

Tax identification number: _____

- B. Bidder holds license number _____, issued on the ____ day of _____, _____, by the Utah State Department of Commerce, Division of Occupational and Professional Licensing. Bidder is licensed to practice as a _____ Contractor. License renewal date is the ____ day of _____, _____.

- C. The undersigned hereby acknowledges receipt of the following Addenda.

(list Addenda numbers here)

1.02 BIDDER'S SUBSCRIPTION

- A. Date: _____

- B. Bidder's Signature: _____

- C. Please print Bidder's name here: _____

- D. Title: _____

END OF SECTION

SECTION 00 42 00

BID BOND

PART 1 - GENERAL

1.01 PROCEDURE

- A. For filing purposes, add Bid Bond to the Contract Documents following this page.

END OF SECTION

SECTION 00 43 00

BID SCHEDULE

PART 1 - GENERAL

1.01 DOCUMENT INCLUDES

- A. Price schedules.
- B. Measurement and payment provisions.

1.02 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project.

1.03 REFERENCES

- A. APWA 01 29 00: Payment Procedures.
- B. Document 00 52 00: Agreement.

1.04 SCHEDULES TO BE ADDED TO THE AGREEMENT

- A. This document will be added to the Agreement by reference.

1.05 FEDERAL FUNDING REQUIREMENTS

- A. Base Bid shall be compliant with federal funding requirements identified in Section 00 45 15.
- B. Federal requirements include compliance with Build America, Buy America (BABA). Base bid shall include cost for compliance with (BABA).
 - 1. Contractor shall indicate all products and materials that cannot comply with BABA.
 - 2. If requested, Contractor shall provide the cost deduct for supply of product(s) or material(s) that are not compliant with BABA.
- C. Contractor shall prepare an alternate bid for compliance with the federal requirements identified in Section 00 45 15 excluding BABA. The Owner may choose to seek a waiver for BABA compliance. The Owner reserves the right to award the project based on the base bid or the non-BABA compliant bid alternate. The bid alternate bid schedules are provided in Attachment A of this Section.

1.06 BID ACCEPTANCE

- A. Bids are subject to acceptance for 60 days per Section 00 21 13.

- B. Where noted in the bid schedule, Contractor shall include a cost contingency after the bid for acceptance of bid for up to an additional 60 days, or 120 days from the bid opening. The contingency shall only be used in the event a bid is not accepted within the defined bid acceptance time and shall be prorated based on the duration is held after the initial 60 day acceptance period.

PART 2 - PRICE SCHEDULES

SCHEDULE A – MAIN PLANT SITE BASE BID

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
A1	Mobilization / Demobilization	1	LS		\$
A2	Site Safety & Pedestrian and Traffic Control	1	LS		\$
A3	Quality Control and Materials Testing	1	LS		\$
A4	Construction Surveying	1	LS		\$
A5	Development and Implementation of SWPPP	1	LS		\$
A6	Demolition of Existing Structures	1	LS		\$
A7	Site Clearing, Grubbing, and Stripping	1	LS		\$
A8	Site Excavation and Shoring	1	LS		\$
A9	Ground Improvements	1	LS		\$
A10	Site Dewatering	1	LS		\$
A11	UF Membrane Filtration Units	13	EA	\$	\$
A12	UF Feed Vertical Turbine Pumps	13	EA	\$	\$
A13	High Service Vertical Turbine Pumps (10 MGD)	3	EA	\$	\$
A14	High Service Vertical Turbine Pumps (5 MGD)	2	EA	\$	\$
A15	Water Treatment Plant Facility (Plant Area 10)	1	LS		\$
A16	2 MG Clearwell (Plant Area 20)	1	LS		\$
A17	High Service Pump Station (Plant Area 20)	1	LS		\$
A18	Concrete Diversion Box	1	LS		\$
A19	Coagulant Injection Vault	1	LS		\$
A20	Site Storm Drain Pipe	551	LF	\$	\$
A21	42-inch RCP Overflow Pipe	52	LF	\$	\$
A22	6-inch DI Pipe, Fire Hydrant, and Connection	1	LF	\$	\$
A23	6-inch DI Fire Service Connection	1	LF	\$	\$
A24	12-inch PVC Sanitary Sewer Connection	1	LF	\$	\$
A25	42-inch HDPE Raw Water Pipeline	168	LF	\$	\$
A26	42-inch RCP Mill Race Pipeline	545	LF	\$	\$
A27	42-inch Steel Raw Water Pipe	126	LF	\$	\$
A28	12-inch Steel MW Pipe	72	LF	\$	\$
A29	12-inch Steel RW Pipe	77	LF	\$	\$
A30	10-inch Steel BRW Pipe	93	LF	\$	\$
A31	42-inch Steel Ozonated Water Pipe	99	LF	\$	\$
A32	42-inch Steel Finished Water Pipe	163	LF	\$	\$
A33	Chain Link Fence and Swing Gates	1	LS	\$	\$
A34	2-inch PE Water Service Connection and Pipe	1	LS		\$
A35	4-inch PE Natural Gas Pipe (Dominion Energy)	493	LF	\$	\$
A36	Site PE Natural Gas Piping	1	LS		\$

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
A37	Chemical Solution & Sampling Piping and Vaults	1	LS		\$
A38	6-inch PVC Miscellaneous Storm Drain Piping	1	LS		\$
A39	Concrete Retaining Wall and CMU Screen Wall	1	LS	\$	\$
A40	Large Block Retaining Wall	1	LS	\$	\$
A41	Concrete Generator Pads and Slab-on-Grade	1	LS	\$	\$
A42	1,000kW Natural Gas Generators	3	EA	\$	\$
A43	Drain Vault and Emergency Overflow Box	1	LS		\$
A44	Site Backfill, Grading, and Compaction	1	LS		\$
A45	Site Concrete Entrances	2	EA	\$	\$
A46	Freedom Blvd Concrete Sidewalk	397	LF	\$	\$
A47	Site Concrete Curb and Gutter	1,060	LF	\$	\$
A48	Site Concrete Slab-on-Grade	9,161	SF	\$	\$
A49	Site AC Pavement	3,631	SY	\$	\$
A50	Site Lighting and Security Cameras	1	LS		\$
A51	Site Continuous Louver Blade Screen Walls	1	LS		\$
A52	Site Landscaping and Irrigation System	1	LS		\$
A53	River Diversion Water Quality Sensors	1	LS		\$
A54	Allowance for Laboratory Equipment	1	AC		\$250,000
A55	Allowance for Tools	1	AC		\$20,000
A56	System Testing and Start-up	1	LS		\$
BID SCHEDULE A BASE BID TOTAL				\$	
Cost Contingency for Holding Bid up to 120 days				\$	

SCHEDULE B – 36-INCH TRANSMISSION PIPELINE BASE BID

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
B1	Mobilization / Demobilization	1	LS		\$
B2	Site Safety & Pedestrian and Traffic Control	1	LS		\$
B3	Quality Control and Materials Testing	1	LS		\$
B4	Construction Surveying	1	LS		\$
B5	Development and Implementation of SWPPP	1	LS		\$
B6	6-inch Waterline Loop	1	LS		\$
B7	36-inch Ductile Iron Transmission Pipeline	2,143	LF	\$	\$
B8	36-inch Ductile Iron Tees and 12" Butterfly Valves	2	EA	\$	\$
B9	36-inch Ductile Iron 22.5-deg Elbows	4	EA	\$	\$
B10	36-inch Ductile Iron 45-deg Elbows	4	EA	\$	\$
B11	Transmission Pipeline Trench Over-Excavation & Stabilization	55	CY	\$	\$
B12	Air Valve Vault	2	EA	\$	\$
B13	Valve Vault	1	LS		\$
B14	20-inch Connection	1	LS		\$
B15	36-inch Steel Pipeline (Stations 1+24 to 1+41)	17	LF	\$	\$
B16	36-inch Steel Pipeline (Stations 10+23 to 11+19)	96	LF	\$	\$
B17	36-inch Steel Pipeline (Stations 18+26 to 20+30)	204	LF	\$	\$
B18	Asphalt Restoration - Freedom Blvd & BYU Property	4,075	SY	\$	\$
B19	Asphalt Restoration - University Avenue	295	SY	\$	\$

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
B20	36" Transmission Main Commissioning	1	LS		
BID SCHEDULE B BASE BID TOTAL				\$	
Cost Contingency for Holding Bid up to 120 days				\$	

SCHEDULE A+B

Total of Base Bid Schedule A and Base Bid Schedule B = Total Bid Price (not including cost contingency for holding bid)				\$	
(In words)					

SCHEDULE C – ADDITIVE BID ITEMS

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
C1	Beck Electric Actuators	1	LS		\$
BID SCHEDULE C – ADDITIVE BID ITEMS BID TOTAL				\$	

SCHEDULE D – DEDUCTIVE ALTERNATE

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
D1	20 MGD Capacity Plant	1	LS		\$
BID SCHEDULE D – DEDUCTIVE ALTERNATE BID TOTAL				\$	

NON-BABA COMPLIANT ALTERNATE BID SCHEDULES A-D (From Attachment A)

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
ALT-A	30 MGD Capacity Plant	1	LS		\$
ALT-B	36-Inch Transmission Pipeline	1	LS		\$
ALT-C	Beck Electric Actuators	1	LS		\$
ALT-D	20 MGD Capacity Plant	1	LS		\$

PART 3 - MEASUREMENT AND PAYMENT

3.01 GENERAL

- A. Units of measurement are listed above in the price schedule(s).
- B. See measurement and payment procedures in APWA Section 01 29 00 and modifications herein. Measurement methods are identified in paragraph 3.02 below. Basis of payment is identified in paragraph 3.02 below.

- C. Engineer will take all measurements and compute all quantities.
- D. Contractor will verify Engineer's measurements and computations.
- E. Contractor will provide all equipment, workers, and survey crews to assist Engineer in making measurements.
- F. Contractor responsible for the preservation of neighboring facilities not being demolished, if damage occurs during construction proper restoration of all damage is required at no additional cost. All shall be included in the Bid Item.

3.02 BID SCHEDULE A

A. BID ITEM NO. A1 - "MOBILIZATION / DEMOBILIZATION"

1. GENERAL This bid item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations not normally attributed to any other single bid item within this schedule. This shall include, but is not limited to, work described or enumerated in Section 01 71 13. "Mobilization/Demobilization" shall not exceed 8% of the sum total of Bid Items A2 through A55.
2. METHOD OF MEASUREMENT "Mobilization / Demobilization" shall not be measured, but shall be paid for on a lump sum basis for the completion of the work as required in Section 01 71 13 - Mobilization.
3. BASIS OF PAYMENT Payment for "Mobilization / Demobilization" will be made at the contract lump sum bid price. Payments will be made in accordance with the following schedule:
 - a. When 5% of the original contract amount is earned, 40% of the amount bid for mobilization will be paid.
 - b. When 15% of the original contract amount is earned, an additional 20% for a total of 60% of the amount bid for mobilization will be paid.
 - c. When 40% of the original contract amount is earned, an additional 30% for a total of 90% of the amount bid for mobilization will be paid.
 - d. When 50% of the original contract amount is earned, an additional 10% for a total of 100% of the amount bid for mobilization will be paid.

B. BID ITEM NO. A2 - "SITE SAFETY & PEDESTRIAN AND TRAFFIC CONTROL"

1. GENERAL This bid item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations related to site and pedestrian safety, site security, and pedestrian and vehicle traffic control.

2. METHOD OF MEASUREMENT "Site Safety & Pedestrian and Traffic Control" shall not be measured, but shall be paid for on a lump sum basis for the completion of the work.
3. BASIS OF PAYMENT Payment for "Site Safety & Pedestrian and Traffic Control" will be made at the contract lump sum bid price. Payments will be made in accordance with the following schedule:
 - a. When 5% of the original contract amount is earned, 50% of the amount bid for mobilization will be paid.
 - b. When 50% of the original contract amount is earned, an additional 30% for a total of 90% of the amount bid for mobilization will be paid.
 - c. When 90% of the original contract amount is earned, an additional 20% for a total of 100% of the amount bid for mobilization will be paid.

C. **BID ITEM NO. A3 - "QUALITY CONTROL AND MATERIALS TESTING"**

1. GENERAL This item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations associated with Quality Control and Materials Testing. This item shall include, but is not limited to, work described or enumerated in Section 01 45 33 and Section 01 43 00.
2. METHOD OF MEASUREMENT "Quality Control and Materials Testing" shall be measured based on the percentage of work completed for the project according to the amount defined in the Bid Schedule.
3. BASIS OF PAYMENT Payment for "Quality Control and Materials Testing" will be made at the contract lump sum bid price as shown and accepted by the Owner and ENGINEER in the Bid Schedule. Payments will be made in accordance with the following schedule:
 - a. When 10% of the original contract amount is earned, 25% of the amount bid for material testing will be paid.
 - b. When 25% of the original contract amount is earned, an additional 25% for a total of 50% of the amount bid for material testing will be paid.
 - c. When 50% of the original contract amount is earned, an additional 25% for a total of 75% of the amount bid for material testing will be paid.
 - d. When 75% of the original contract amount is earned, an additional 25% for a total of 100% of the amount bid for material testing will be paid.

D. BID ITEM NO. A4 - "CONSTRUCTION SURVEYING"

1. GENERAL This item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations associated with Construction Surveying, which shall be performed by a registered professional land surveyor.
2. METHOD OF MEASUREMENT "Construction Surveying" shall be measured based on the percentage of work completed for the project according to the amount defined in the Bid Schedule.
3. BASIS OF PAYMENT Payment for "Construction Surveying" will be made at the contract lump sum bid price as shown and accepted by the Owner and the Engineer in the Bid Schedule. Payments will be made in accordance with the following schedule:
 - a. When 5% of the original contract amount is earned, 75% of the amount bid for construction surveying will be paid.
 - b. When 75% of the original contract amount is earned, an additional 25% for a total of 100% of the amount bid for construction surveying will be paid.

E. BID ITEM NO. A5 - "DEVELOPMENT AND IMPLEMENTATION OF SWPPP"

1. METHOD OF MEASUREMENT "Development and Implementation of SWPPP (Storm Water Pollution Prevention Plan)" shall be paid for on a lump sum basis for preparation and implementation of the approved Plan as completed by the Contractor.
2. BASIS OF PAYMENT "Development and Implementation of the SWPPP" shall be paid for at the lump sum bid price as a percentage of work completed. Payment shall be considered full compensation for completion of an approved plan and implementation thereof. The implementation shall include installing and maintaining Best Management Practices defined in the SWPPP, and monitoring and maintaining the requirements of the SWPPP, preparation of required reports, and meeting all other requirements of the Utah Division of Water Quality.

F. BID ITEM NO. A6 - "DEMOLITION OF EXISTING STRUCTURES"

1. METHOD OF MEASUREMENT "Demolition of Existing Structures" shall be paid for on a lump sum basis for demolition of existing structures according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for the "Site Demolition" shall be considered full compensation for the demolition and disposal as shown on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; saw cutting, demolition of concrete walkways and curbing, demolition of asphalt pavements; coordinating power disconnection with Provo Power, excavations, removal of power poles,

removal of light poles and bases, removal of buried and overhead power lines; hauling debris and material off-site to an approved landfill or recycling facility; and all other incidentals required to complete the demolition as required to construct the new and future facilities specified herein and shown on the Contract Documents.

G. BID ITEM NO. A7 - "SITE CLEARING, GRUBBING, AND STRIPPING"

1. METHOD OF MEASUREMENT "Site Clearing, Grubbing, and Stripping" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "Site Clearing, Grubbing, and Stripping" shall be made at the contract lump sum bid price for the Contractor to remove, transport, disposal, applicable dumping fees, cleanup of waste materials, and related costs for clearing, grubbing, and stripping which includes removing all unwanted material from the surface and subsurface within the project limits such as trees, vegetation, boulders, stumps, roots, buried logs, and other debris; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings.

H. BID ITEM NO. A8 - "SITE EXCAVATION AND SHORING"

1. METHOD OF MEASUREMENT "Site Excavation and Shoring" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "Site Excavation and Shoring" shall be considered full compensation for all work completed under this bid item and shall be made at the contract lump sum bid price. Payment shall be considered complete compensation for design of the shoring system and furnishing all labor, materials and equipment required for installation and removal of the shoring system, excavation, and disposal of site soils to grades shown on plans, hauling, off-site disposal of surplus and unsuitable material, stockpiling of suitable material, and other items necessary for the shoring, excavation, and disposal as shown on the Contract Documents.

I. BID ITEM NO. A9 - "GROUND IMPROVEMENTS"

1. GENERAL Soil Mix Columns OR Aggregate columns are acceptable methods for ground improvements. Contractor shall bid preferred method in accordance with *Section 31 24 02 Ground Improvement Using Soil Mix Columns* OR *31 24 03 Ground Improvement Using Aggregate Columns*. Method submitted must meet the specified performance requirements.
2. METHOD OF MEASUREMENT "Ground Improvements" shall not be measured, but shall be paid for on a lump sum basis for design and construction of ground improvements or intermediate foundations beneath the water treatment plant,

Clearwell, and High Service Pump Station in accordance with Section 31 24 02 or Section 31 24 03 based on the method proposed by the Contractor and Approved by the Engineer.

3. BASIS OF PAYMENT Payment for "Ground Improvements " shall be paid for at the lump sum bid price. Payment shall be considered full compensation for design and construction of intermediate foundations beneath the Water Treatment Plant Facility including the Administration Building, Clearwell, and High Service Pump Station area, including sufficient distance outside of the footprint of the footings to accomplish design objectives of providing adequate net bearing capacity for the structures and reducing liquefaction potential to an acceptable limit. Payment shall be considered complete compensation for all labor, equipment, and materials, including but not limited to: design, design submittals (including detailed design calculations, construction drawings and shop drawings), quality control testing program for soil mix columns or aggregate columns meeting design requirements, construction of the most efficient and cost-effective ground improvement method, load transfer pad if required, verification testing, daily progress reports, and all other incidentals not specifically paid for in other bid items but which are otherwise required to complete required ground improvements and shown on the Contract Drawings and Specifications.

J. BID ITEM NO. A10 - "SITE DEWATERING"

1. METHOD OF MEASUREMENT "Site Dewatering" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "Site Dewatering" shall be made at the contract unit lump sum bid price for analyzing, designing, furnishing, and installation the site dewatering in order to facilitate site excavations. Payment shall be considered complete compensation for design of the dewatering system and furnishing all labor, equipment, and materials to install and maintain the dewatering system to allow excavation to the grades as shown on the Contract Drawings and paid for under Bid Item No. A8, permitting, treatment and testing (if required), disposal and/or storage of water, and all other incidentals not specifically paid for in other bid items, but which are shown or otherwise required to complete the installation as herein described.

K. BID ITEM NO. A11 - "UF MEMBRANE FILTRATION UNITS"

1. METHOD OF MEASUREMENT "UF Membrane Filtration Units" shall be measured by each UF Membrane Unit skid furnished and installed according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "UF Membrane Filtration Units" shall be made at the contract unit bid price per each UF Membrane Unit skid, with accompanying appurtenances furnished and installed. Work shall also include connections to

pipng, testing, and all other related items not paid elsewhere as shown on the Contract Drawings and in the Specifications. (Electrical connections paid as part of Bid Item A15).)

L. BID ITEM NO. A12 - "UF FEED VERTICAL TURBINE PUMPS"

1. METHOD OF MEASUREMENT "UF Feed Vertical Turbine Pumps" shall be measured by each pump and motor furnished and installed according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "UF Feed Vertical Turbine Pumps" shall be paid at the contract unit bid price per each pump and motor, with accompanying appurtenances furnished and installed. Work shall also include furnishing and installing discharge heads, pump cans; sleeves, and washers; pump bowls, shafting, columns, motors, testing, and all other pump related items not paid elsewhere as shown on the Contract Drawings and in the Specifications. (Electrical gear and connections paid as part of Bid Item A15.)

M. BID ITEM NO. A13 - "HIGH SERVICE VERTICAL TURBINE PUMPS (10 MGD)"

1. METHOD OF MEASUREMENT "High Service Vertical Turbine Pumps (10 MGD)" shall be measured by each pump and motor furnished and installed according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "High Service Vertical Turbine Pumps (10 MGD)" shall be paid at the contract unit bid price per each pump and motor, with accompanying appurtenances furnished and installed. Work shall also include furnishing and installing discharge heads, pump cans; barrel isolation sheet, sleeves, and washers; pump bowls, shafting, columns, motors, testing, and all other pump related items not paid elsewhere as shown on the Contract Drawings and in the Specifications. (Electrical gear and connections paid as part of Bid Item A17.)

N. BID ITEM NO. A14 - "HIGH SERVICE VERTICAL TURBINE PUMPS (5 MGD)"

1. METHOD OF MEASUREMENT "High Service Vertical Turbine Pumps (5 MGD)" shall be measured by each pump and motor furnished and installed according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "High Service Vertical Turbine Pumps (5 MGD)" shall be paid at the contract unit bid price per each pump and motor, with accompanying appurtenances furnished and installed. Work shall also include furnishing and installing discharge heads, pump cans; barrel isolation sheet, sleeves, and washers; pump bowls, shafting, columns, motors, testing, and all other pump related items not paid elsewhere as shown on the Contract Drawings and in the Specifications. (Electrical gear and connections paid as part of Bid Item A17.)

O. BID ITEM NO. A15 - "WATER TREATMENT PLANT FACILITY (PLANT AREA 10)"

1. METHOD OF MEASUREMENT Measurement for "Water Treatment Plant Facility (Plant Area 10)" work completed according to the amount defined in the Bid Schedule shall be based on the Schedule of Values to be provided by the Contractor prior to beginning the Work. Measurement shall begin at all piping connections shall begin at 5 feet from the outside edge of the building unless otherwise noted on the Contract Drawings.
2. BASIS OF PAYMENT Payment for "Water Treatment Plant Facility (Plant Area 10)" shall be made at the contract unit lump sum bid price for completion of the Water Treatment Plant Facility including Administration Building as shown on the Contract Drawings and specified herein. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; imported structure fill and compaction; concrete, reinforcement, forms, waterstop, concrete placement, curing; structural steel, CMU block, open web steel roof joists, roof decking, roof membrane, insulation, metal panels, louvers, windows, access doors, overhead coiling doors, and door hardware; 4 ton overhead bridge crane; water treatment system piping, valves, meters, and fittings; installation of vertical turbine pump cans (furnished in bid item A12); chlorination system and air scrubber; ozone system and liquid oxygen tank; chemical solution tanks, pumps, piping and fittings; office furniture and finishes, lab cabinets and equipment not included in Bid Item 53 below; electrical panels, MCCs, lighting, ground system, and miscellaneous gear; control panels and instrumentation; HVAC systems and controls; fire systems; security and access systems; coatings, finishes, and flooring; disinfection and testing, and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required for a complete and operational water treatment facility assembly as herein described and as shown on the Contract Drawings .

P. BID ITEM NO. A16 - "2 MG CLEARWELL (PLANT AREA 20)"

1. METHOD OF MEASUREMENT Measurement for "2 MG Clearwell (Plant Area 20)" work completed according to the amount defined in the Bid Schedule shall be based on the Schedule of Values to be provided by the Contractor prior to beginning the Work. Measurement shall begin at all piping connections shall begin at 5 feet from the outside edge of the building or nearest joint outside the Clearwell unless otherwise noted on the Contract Drawings.
2. BASIS OF PAYMENT Payment for "2 MG Clearwell (Plant Area 20)" shall be made at the contract unit lump sum bid price for completion of the 2 MG Clearwell as shown on the Contract Drawings and specified herein. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, the Clearwell 42-inch diameter emergency overflow piping, 42-inch diameter inlet pipes and fittings, 42-inch butterfly valves, 42-inch diameter outlet pipe and fittings, 36-inch stainless steel slide gates with

handwheels, 8-inch diameter drain pipe and fittings, 4-inch diameter wash down pipes and fittings, providing joint restraint on all fittings and valves and on pipes as designated, concrete encasement with reinforcement around all pipes under Clearwell; furnishing, placement, and installation of all concrete form work, formliners, reinforcement, shoring, concrete materials, curing, removal of forms; foundation preparation; 3/4-inch drain rock under tank floor slab and footings; interior ladders, guard rails, grates, hatches, vents and covers; FRP baffles walls and supports; 10-inch pressure relief valves and piping, 4-inch diameter stainless steel ozone piping, expansion joints, fittings, and supports; galvanized steel stairs with handrailing; gravel rock cover, 1-inch diameter PVC pipe drains, water stops, concrete staining, graffiti coat; commissioning of tank (including cleaning and flushing, disinfection and leak testing); painting all exposed piping excluding stainless steel piping; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings.

Q. BID ITEM NO. A17 - "HIGH SERVICE PUMP STATION (PLANT AREA 20)"

1. **METHOD OF MEASUREMENT** "High Service Pump Station (Plant Area 20)" work completed according to the amount defined in the Bid Schedule shall be based on the Schedule of Values to be provided by the Contractor prior to beginning the Work. Measurement shall begin at all piping connections shall begin at buttstrap connection 5-feet from valve pit wall on the suction side and end at the buttstrap connection approximately 37-feet from the outside edge of the building on the discharge side.
2. **BASIS OF PAYMENT** Payment for "High Service Pump Station (Plant Area 20)" shall be considered full compensation for installation of the High Service Pump Station as shown on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, imported structure fill and compaction; concrete, reinforcement, forms, waterstop, concrete placement, curing; structural steel supports and grating, ladders, CMU block, open web steel roof joists, roof decking, roof membrane, insulation, metal panels, louvers, windows, access doors, overhead coiling door, and door hardware; 2-ton monorail crane; suction and discharge piping, valves, couplings, restraints, meters, and fittings; ozone destruct units and piping; bladder style surge tanks; electrical panels, MCCs, lighting, ground system, and miscellaneous gear; control panels and instrumentation; HVAC systems and controls; security and access systems; coatings and finishes; disinfection and testing, and all other operations and materials and appurtenances required for a complete and operational pump station as herein described and as shown on the Contract Drawings.

R. BID ITEM NO. A18 - "CONCRETE DIVERSION BOX"

1. **METHOD OF MEASUREMENT** "Concrete Diversion Box" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.

2. BASIS OF PAYMENT Payment for “Concrete Diversion Box ” shall be made at the contract unit lump sum bid price for construction of a new concrete diversion box and slide gates as shown on the Contract Drawings and specified herein. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; (2) aluminum slide gates, electric gate actuators, adjustable stainless steel weir plate; cast-in-place concrete, rebar, forms; grating, checkered plates; PVC electrical conduits, and stainless steel water quality sensor pipe, level sensor pipe with level transmitter; 42-inch welded steel wall thimble, 42-inch ductile iron wall thimble, and 3-feet of 42-inch reinforced concrete pipes; 48-inch high PVC coated chain link fencing; native material backfill and compaction; structural fill, geotextile fabric, testing; and all other components required on the Contract Drawings and as specified herein. This bid item does not include payment for the 12-foot section of retaining wall south of diversion box, which is paid for under Bid Item No. 39.

S. BID ITEM NO. A19 - “COAGULANT INJECTION VAULT”

1. METHOD OF MEASUREMENT “Coagulant Injection Vault” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “Coagulant Injection Vault” shall be made at the contract unit lump sum bid price for construction of a new concrete coagulant injection vault as shown on the Contract Drawings and specified herein. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; excavation, shoring, and 3/4-inch drain rock; cast-in-place concrete, rebar, forms, placement, and curing; access hatches, ladders, pipe sleeves, and grating; pipe flash reactor assembly, 42-inch diameter steel pipe from bolted sleeve coupling outside of Diversion Box, through vault, and ending at buttstrap connection outside the vault; bolted sleeve coupling, dismantling joint, and buttstrap; irrigation piping, valves, pump, and flow meter; 10-inch steel branch outlet, coupling, and butterfly valve; 12-inch steel pipe and fittings internal to vault to to buttstrap connections outside of the vault; 3-inch diameter PVC conduit and fittings, 3/4-inch diameter tubing, and chemical injection quill; sump pump, sump pump pipe and fittings; mechanical pipe seals; exhaust fan, vent piping, and screened vent caps; coatings, disinfection and testing; native material backfill and compaction; and all other components required on the Contract Drawings and as specified herein.
3. BID ITEM NO. A20 "SITE STORM DRAIN PIPE”
4. METHOD OF MEASUREMENT “Site Storm Drain Pipe” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot.

Measurement shall include storm drainpipe shown on Sheets 01-C301 (including the 54 feet of 8-inch pipe and area inlet) and 01-C302 and start at the Catch Basin Sta 1+00 and end at, but not include, the Cleanout Box Sta 6+09.70 (Cleanout Box is included in Bid Item No. 26).

5. BASIS OF PAYMENT Payment for "Site Storm Drain Pipe" shall be paid for at the contract unit bid price per lineal foot listed in the bidder's proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the storm drain pipes to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 6-inch diameter, 8-inch diameter, 15-inch diameter, and 18-inch diameter PVC SDR 35 pipe and fittings, 3/4-inch washed gravel bedding, haunch, and pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to cleanout box, precast concrete catch basins, cast-in-place concrete cleanout box and area inlet, precast concrete dry sump manholes, grates, ring and covers, treatment snouts; protection of buried utilities, potholing as needed; all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

T. BID ITEM NO. A21 - "42-INCH RCP OVERFLOW PIPE"

1. METHOD OF MEASUREMENT "42-inch RCP Overflow Pipe" shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall include the overflow pipe on Sheet 01-C303 and shall start at the connection to the Emergency Overflow Box and end, but not include, the Cleanout Box Sta 1+51.64 (Cleanout Box is included in Bid Item No. 26).
2. BASIS OF PAYMENT Payment for "42-inch RCP Overflow Pipe" shall be paid at the contract unit bid price per lineal foot listed in the bidder's proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the overflow pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 42-inch diameter RCP Class III pipe, 3/4-inch washed gravel bedding, haunch, and pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connections, protection of buried utilities, potholing as needed; all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

U. BID ITEM NO. A22 - "6-INCH DI PIPE, FIRE HYDRANT, AND CONNECTION"

1. METHOD OF MEASUREMENT “6-inch DI Pipe, Fire Hydrant, and Connection” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall include the pipe shown on Sheet 01-C304 and start at the Fire Hydrant (Sta 10+00) and end at the connection to the existing 20-inch pipeline in Freedom Blvd (Sta. 10+44.15).
2. BASIS OF PAYMENT Payment for “6-inch DI Pipe, Fire Hydrant, and Connection” shall be made at the contract unit lump sum bid price for installing the 6-inch ductile iron pipe as shown on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, saw cutting and removal and disposal of existing AC pavement, excavation, dewatering, shoring; installing new 6-inch diameter ductile iron PC 250 pipe and fittings, 20-inch diameter hot tap, 6-inch diameter gate valve, tracer wire, thrust blocks, restraints, sand pipe zone backfill, native and/or imported trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning and flushing, disinfection and pressure testing); protection of buried utilities, potholing as needed; AC pavement restoration and striping; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

V. BID ITEM NO. A23 – “6-INCH FIRE SERVICE CONNECTION”

1. METHOD OF MEASUREMENT “6-inch Fire Service Connection” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall include the pipe shown on Sheet 01-C305 and start at the connection 5-feet from the WTP (Sta 1+00) and end at the connection to the existing 20-inch pipeline in Freedom Blvd (Sta. 2+14.53).
2. BASIS OF PAYMENT Payment for “6-inch Fire Service Connection” shall be made at the contract unit lump sum bid price for installing the 6-inch ductile iron pipe as shown on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, saw cutting and removal and disposal of existing AC pavement, excavation, dewatering, shoring; installing new 6-inch diameter ductile iron PC 250 pipe and fittings, 20-inch diameter hot tap, 6-inch diameter gate valve, tracer wire, thrust blocks, restraints, sand pipe zone backfill, native and/or imported trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning and flushing, disinfection and

pressure testing); protection of buried utilities, potholing as needed; AC pavement restoration and striping; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

W. BID ITEM NO. A24 – “12-INCH PVC SANITARY SEWER CONNECTION”

1. METHOD OF MEASUREMENT “12-inch PVC Sanitary Sewer Connection” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall include sanitary sewer pipe shown on Sheets 01-C306 and start at the connection 5-feet from the WTP (Sta 1+00) and end at the connection to the existing 5-foot diameter manhole (Sta 1+89.55).
2. BASIS OF PAYMENT Payment for “12-inch PVC Sanitary Sewer Connection” shall be made paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the sanitary sewer pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 12-inch diameter SDR 35 pipe and fittings, 3/4-inch washed gravel bedding, haunch, and pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning and testing); connection to the WTP, 5-foot diameter precast concrete manhole, connection to precast concrete manhole, ring and cover, flexible boots; protection of buried utilities, potholing as needed; AC pavement restoration and striping; all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

X. BID ITEM NO. A25 – “42-INCH HDPE RAW WATER PIPELINE”

1. METHOD OF MEASUREMENT “42-inch HDPE Raw Water Pipeline” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the connection to the existing 42-inch HDPE pipeline and end with the 42-inch ductile iron long sleeve outside the diversion box.
2. BASIS OF PAYMENT Payment for “42-inch HDPE Raw Water Pipeline” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 42-inch HDPE pipe to make a functional system including, but not limited to, pavement saw cutting and removal,

excavation, dewatering, shoring; installing the 42-inch HDPE IPS DR 32.5 pipe and fittings, CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; protection of buried utilities, potholing as needed, restoration of all surface improvements, disconnection, removal, and plugging of existing 30-inch storm drain; fence removal and replacement, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

Y. BID ITEM NO. A26 – “42-INCH RCP MILL RACE PIPELINE”

1. METHOD OF MEASUREMENT “42-inch RCP Mill Race Pipeline” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the connection to the 42-inch stub at the diversion box and end with the 6’x6’ cast-in-place curb inlet box.
2. BASIS OF PAYMENT Payment for “42-inch RCP Mill Race Pipeline” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the RCP pipe, Boxes, and Area Inlets to make a functional system including, but not limited to pavement saw cutting and removal, excavation, removal and off-site disposal of existing storm drainage pipes and existing structures; dewatering, shoring; installing the 42-inch, 24-inch, and 15-inch diameter Class III RCP, imported pipe zone backfill, native and/or imported trench zone backfill, native fill overburn and open channel infill, fills compaction; installing the area inlet boxes and cleanout boxes; installing the cast-in-place curb inlet box including backfilling, concrete, rebar, and forms; concrete waterway, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); provisions for testing the pipeline; protection of buried utilities, potholing as needed, connections to existing pipes; final grading, surface restoration, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

Z. BID ITEM NO. A27 – “42-INCH STEEL RAW WATER PIPE”

1. METHOD OF MEASUREMENT “42-inch Steel Raw Water Pipeline” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per

foot. Measurement shall start at the buttstrap connection to the Coagulant Injection Vault and end with the 42-inch diameter sleeve 5-feet from the WTP.

2. BASIS OF PAYMENT Payment for “42-inch Steel Raw Water Pipeline” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 42-inch diameter steel pipe and fittings to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 42-inch diameter steel pipe and fittings, CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; fence removal and replacement, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

AA. BID ITEM NO. A28 – “12-INCH STEEL MW PIPE”

1. METHOD OF MEASUREMENT “12-inch Steel MW Pipe” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the buttstrap connection to the Coagulant Injection Vault and end 5-feet from the WTP.
2. BASIS OF PAYMENT Payment for “12-inch Steel MW Pipe” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 12-inch diameter steel pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 12-inch diameter steel pipe and fittings, CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; fence removal and replacement, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

BB. BID ITEM NO. A29 – “12-INCH STEEL RW PIPE”

1. METHOD OF MEASUREMENT “12-inch Steel RW Pipe” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor

shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the buttstrap connection outside the Coagulant Injection Vault and end 5-feet from the WTP.

2. BASIS OF PAYMENT Payment for “12-inch Steel RW Pipe” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 12-inch diameter steel pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 12-inch diameter steel pipe and fittings, CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; fence removal and replacement, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

CC. BID ITEM NO. A30 – “10-INCH STEEL BRW PIPE”

1. METHOD OF MEASUREMENT “10-inch Steel BRW Pipe” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the 10” gate valve connected to the 42-inch diameter Steel Raw Water Pipe and end with the restrained coupling approximately 5-feet from the WTP.
2. BASIS OF PAYMENT Payment for “10-inch Steel BRW Pipe” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 10-inch diameter steel pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 10-inch diameter steel pipe and fittings, 10-inch gate vault with valve box; CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; fence removal and replacement, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

DD. BID ITEM NO. A31 – “42-INCH STEEL OZONATED WATER PIPE”

1. METHOD OF MEASUREMENT “42-inch Steel Ozonated Water Pipe” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the

horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the butt strap connection to the 42-inch diameter sleeve 5-feet from the WTP and end at the butt straps at the Clearwell.

2. **BASIS OF PAYMENT** Payment for “42-inch Steel Ozonated Pipe” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 42-inch diameter steel pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 42-inch diameter steel pipe and fittings, steel butt straps, CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; ; fence removal and replacement, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

EE. BID ITEM NO. A32 – “42-INCH STEEL FINISHED WATER PIPE”

1. **METHOD OF MEASUREMENT** “42-inch Steel Finished Water Pipeline” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the buttstrap connection outside the Clearwell and end at the buttstrap connection to the Pump Station.
2. **BASIS OF PAYMENT** Payment for “42-inch Steel Finished Water Pipeline” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 42-inch diameter steel pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 42-inch diameter steel pipe and fittings, CLSM pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline;, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

FF. BID ITEM NO. A33 – “CHAIN LINK FENCE AND SWING GATES”

1. **METHOD OF MEASUREMENT** “Chain Link Fence and Swing Gates” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.

2. BASIS OF PAYMENT Payment for “Chain Link Fence and Swing Gates” shall be considered full compensation for furnishing and installing the chain link fence and swing gates as identified on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, new 6’ Black Vinyl Coated Chain Link Fence, post excavation, concrete, gates, hardware, gate keepers; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

GG. BID ITEM NO. A34 – “2-INCH PE WATER SERVICE CONNECTION AND PIPE”

1. METHOD OF MEASUREMENT “2-inch PE Water Service Connection and Pipe” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by CONTRACTOR.
2. BASIS OF PAYMENT Payment for “2-inch PE Water Service Connection and Pipe” shall be considered full compensation for furnishing and installing the 2-inch diameter PE water service pipe as identified on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; installing the 2-inch polyethylene pipe and fittings, meter setting, meter box; pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning, flushing, and testing); connection to existing pipe, provisions for testing the pipeline; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

HH. BID ITEM NO. A35 – “4-INCH PE NATURAL GAS PIPE (DOMINION ENERGY)”

1. METHOD OF MEASUREMENT “4-inch PE Natural Gas Pipe (Dominion Energy)” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the connection to the existing 6-inch natural gas pipe and end at the connection to the new gas flow meter assembly installed by Dominion Energy.
2. BASIS OF PAYMENT Payment for “4-inch PE Natural Gas Pipe (Dominion Energy)” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the 4-inch diameter PE pipe to make a functional system including, but not limited to, pavement saw cutting and removal, excavation, dewatering, shoring; coordination of installation the 4-inch polyethylene pipe and fittings and connection to the existing 6-inch diameter pipe by Dominion Energy, sand pipe zone backfill, trench zone backfill,

compaction, removal and disposal of excess excavated material; concrete pad for meter assembly; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

II. BID ITEM NO. A36 – “SITE PE NATURAL GAS PIPING”

1. METHOD OF MEASUREMENT “Site PE Natural Gas Piping” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor. Measurement shall begin at the new gas meter assembly (installed by Dominion Energy) and end at the connections to the WTP facility and at the connection to each of the generators.
2. BASIS OF PAYMENT Payment for “Site PE Natural Gas Piping” shall be considered full compensation for furnishing and installing the natural gas piping on the site as identified on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, excavation and shoring; installation the 4-inch diameter and 2-inch diameter polyethylene pipe and fittings, 2-inch diameter HDPE ball valve, tracer wire, 2-inch diameter riser and appurtenances, 4-inch diameter risers and appurtenances; sand pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, testing and commissioning; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

JJ. BID ITEM NO. A37 – “CHEMICAL SOLUTION & SAMPLING PIPING AND VAULTS”

1. METHOD OF MEASUREMENT “Chemical Solution & Sampling Piping and Vaults” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor. Measurement shall begin at the connection to the WTP facility and end at the connections to the Clearwell and High Service Pump Station.
2. BASIS OF PAYMENT Payment for “Chemical Solution & Sampling Piping and Vaults” shall be considered full compensation for furnishing and installing the chemical solution and sampling piping and vaults as identified on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, excavation and shoring; 4-inch diameter casing pipes, chemical solution and sampling tubing and pipes, valves, and fittings; precast concrete vaults, ring and covers, polyethylene manhole steps, pipe supports; sand pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, testing and commissioning; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

KK. BID ITEM NO. A38 – “6-INCH PVC MISCELLANEOUS STORM DRAIN PIPING”

1. **GENERAL** This item includes the three 6-inch diameter storm drain pipes connecting the roof drains from the WTP, Administration Building, and High Service Pump Station to the site storm drain piping including typical connection detail C021 on Sheet 99-C706.
 2. **METHOD OF MEASUREMENT** “6-inch PVC Miscellaneous Storm Drain Piping” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
 3. **BASIS OF PAYMENT** Payment for “6-inch PVC Miscellaneous Storm Drain Piping” shall be considered full compensation for furnishing and installing the storm drain pipes as identified on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to, excavation and shoring; 6-inch diameter PVC SDR 35 pipe and fittings; precast boxes and lids; pipe zone backfill, trench zone backfill, compaction, removal and disposal of excess excavated material, testing and commissioning; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.
- LL. BID ITEM NO. A39 – “CONCRETE RETAINING WALL AND CMU SCREEN WALL”
1. **METHOD OF MEASUREMENT** “Concrete Retaining Wall and CMU Screen Wall” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
 2. **BASIS OF PAYMENT** Payment for “Retaining Wall and CMU Screen Wall” shall be considered full compensation for furnishing and installing the concrete retaining wall, 48-inch high PVC coated chain link fence, and 6-foot high CMU wall as identified on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; excavation, cast-in-place concrete, rebar, forms; 4-inch HDPE perforated drain pipe, non-woven geotextile fabric, and drain rock; native material backfill and compaction, fence posts, fabric, tension wires, and all fence appurtenant items; CMU block, rebar, mortar, precast concrete cap; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the retaining wall and CMU screen wall as herein described and as shown on the Contract Drawings.
- MM. BID ITEM NO. A40 – “LARGE BLOCK RETAINING WALL”
1. **METHOD OF MEASUREMENT** “Large Block Retaining Wall” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
 2. **BASIS OF PAYMENT** Payment for “Large Block Retaining Wall” shall be considered full compensation for furnishing and installing the large block retaining wall, 48-inch high PVC coated chain link fence as identified on the Contract

Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; excavation, cast-in-place concrete, rebar, forms; native material backfill and compaction, fence posts, fabric, tension wires, and all fence appurtenant items; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the retaining wall and fence as herein described and as shown on the Contract Drawings.

NN. BID ITEM NO. 41 – “CONCRETE GENERATOR PADS AND SLAB-ON-GRADE”

1. METHOD OF MEASUREMENT “Concrete Generator Pads and Slab-on-Grade” shall not be measured but shall be paid for on a lump sum unit price basis for the construction of the concrete slab and concrete pads, including all components required on the Contract Drawings and in the Specifications.
2. BASIS OF PAYMENT Payment for “Concrete Generator Pads and Slab-on-Grade” shall be made at the contract unit lump sum bid price for completion of all work as shown on the Contract Drawings and as specified herein, and shall be considered complete compensation for all labor, equipment, and materials necessary, including but not limited to subgrade preparation and compaction; furnishing, installing and compaction of untreated base course material; furnishing, forming and installing concrete and steel reinforcement; expansion boards, sealant; removing forming; saw cutting, curing and all other operations and materials required to complete this portion of the work as required by specifications and as shown on the Contract Drawings.

OO. BID ITEM NO. A42 – “1,000 kW NATURAL GAS GENERATORS”

1. METHOD OF MEASUREMENT “1,000 kW Natural Gas Generators” shall be measured by each 1,000 kW Generator furnished, tested, installed, and O&M materials provided according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “1,000 kW Natural Gas Generators” shall be paid at the contract unit bid price per each listed in the bidder’s proposal and shall be considered full compensation for all work completed under this bid item as shown on the Contract Drawings and as specified herein. Payment shall include, but not be limited to all labor, materials, and equipment for furnishing and installing the new 1,000 kW generators, generator paralleling equipment, automatic transfer switches, load bank, stainless steel epoxy anchor bolts, mounting to concrete pads, buried conduits and wiring, connections, testing, and all other related items as shown on the Contract Drawings not paid elsewhere for a complete and operable backup emergency generator system.

PP. BID ITEM NO. A43 – “DRAIN VAULT AND EMERGENCY OVERFLOW BOX”

1. METHOD OF MEASUREMENT Measurement for “Drain Vault and Emergency Overflow Box” shall be based on percentage of work completed for the project according to the amount defined in the Bid Schedule.
2. BASIS OF PAYMENT Payment for “Drain Vault and Emergency Overflow Box” shall be made at the contract lump sum bid price, including all components required in the Contract Drawings and Specifications. Payment shall be considered complete compensation for all work performed.
 - a. Payment shall include construction of the drain vault, with all associated facilities including but not limited to all labor, equipment, and materials; excavation, dewatering, foundation preparation; compacted drain rock wrapped in filter fabric; vents and inline exhaust fan; furnishing, placement, and installation of all concrete form work, reinforcement, shoring, concrete materials, curing, removal of forms; waterproof membrane with protection board; hatches; painting; ladder, galvanized steel stairs and railing, galvanized steel grating and supports; sump and sump pump; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings.
 - b. Payment shall include 8-inch diameter ductile iron Class 53 inlet piping and solid sleeve fittings from 2-feet outside of the Clearwell to and through the vault; all other piping and fittings inside the vault; 8-inch diameter ductile iron Class 53 discharge pipe and fittings through the vault to and including all piping at the Emergency Overflow Box as shown on the Contract Drawings. Payment shall also include all items referenced in the Drain Vault Pipe, Valve, Fitting, and Pump Schedules on Sheet 20-D601 of the Contract Drawings, including but not limited to gate valves, centrifugal pump; sump pump with valves, hose bibb, and all piping to the Emergency Overflow Box; transmitters; pipe supports; and all other interior piping in the drain vault and emergency overflow structures; all labor, equipment, and materials; furnishing and installing the pipe and associated piping; painting all pipes, valves, and fittings, etc.; restraints on all valves and fittings and on pipeline joints where designated on the Contract Drawings; commissioning of drain vault and emergency overflow box and piping (including cleaning and flushing, disinfection and pressure testing); and all other incidentals and appurtenances not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings. Payment shall be considered complete compensation for all work performed.
 - c. Payment shall include construction of the emergency overflow box, with all associated facilities including but not limited to all labor, equipment, and materials; excavation, dewatering, foundation preparation; untreated base course under box; furnishing, placement, and installation of all concrete form work, reinforcement, shoring, concrete materials, curing, removal of forms;

grates; pipe connection to vault; grout on floor; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings.

QQ. BID ITEM NO. A44 – “SITE BACKFILL, GRADING, AND COMPACTION”

1. METHOD OF MEASUREMENT “Site Backfill and Compaction” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “Site Backfill and Compaction” shall be made at the contract lump sum bid price for backfilling and compacting the site as shown on the Contract Drawings and as specified herein. Payment shall include furnishing all labor, materials and equipment including, but not be limited to, importing common fill material, placing, grading, and compacting; and all other related items as shown on the Contract Drawings not paid elsewhere.

RR. BID ITEM NO. A45 – “SITE CONCRETE ENTRANCES”

1. METHOD OF MEASUREMENT “Site Concrete Entrances” shall be paid for each entrances completed according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “Site Concrete Entrances” shall be made at the contract lump sum bid price for installation of the two new concrete entrances at the site as shown on the Contract Drawings and as specified herein. Payment shall include furnishing all labor, materials and equipment including, but not be limited to, saw cutting existing pavement and curb and gutter, demolition and disposal of material; providing, placing, and compacting untreated base course material; concrete forms, steel reinforcement, concrete, concrete curing and finishing, AC pavement restoration; and all other related items as shown on the Contract Drawings not paid elsewhere.

SS. BID ITEM NO. A46 – “FREEDOM BLVD CONCRETE SIDEWALK”

1. METHOD OF MEASUREMENT “Freedom Blvd Concrete Sidewalk” shall be measured according to the lineal foot of concrete sidewalk acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed sidewalk. This item shall include the additional width as shown at each end to transition to the existing sidewalk.
2. BASIS OF PAYMENT Payment for “Freedom Blvd Concrete Sidewalk” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the concrete sidewalk including, but not limited to, saw cutting existing sidewalk, demolition and disposal of material;

providing, placing, and compacting untreated base course material; concrete forms, concrete, concrete curing and finishing; expansion joint filler material, contraction joint saw cuts; and all other related items as shown on the Contract Drawings not paid elsewhere.

TT. BID ITEM NO. A47 – “SITE CONCRETE CURB AND GUTTER”

1. METHOD OF MEASUREMENT “Site Concrete Curb and Gutter” shall be measured according to the lineal foot of concrete curb and gutter acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed curb and gutter.
2. BASIS OF PAYMENT Payment for “Site Concrete Curb and Gutter” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the concrete curb and gutter including, but not limited to, providing, placing, and compacting untreated base course material; concrete forms, concrete, concrete curing and finishing; expansion joint filler material, contraction joint saw cuts; and all other related items as shown on the Contract Drawings not paid elsewhere.

UU. BID ITEM NO. A48 – “SITE CONCRETE SLAB-OB-GRADE”

1. METHOD OF MEASUREMENT “Site Concrete Slab-on-Grade” shall be measured according to the square foot of concrete slab-on-grade acceptably installed as shown on the Contract Drawings and in the Specifications.
2. BASIS OF PAYMENT Payment for “Site Concrete Slab-on-Grade” shall be paid for at the contract unit bid price per square foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the concrete slab-on-grade including, but not limited to, providing, placing, and compacting untreated base course material; concrete forms, steel reinforcement, concrete, concrete curing and finishing; expansion joint filler material, contraction joint saw cuts; and all other related items as shown on the Contract Drawings not paid elsewhere.

VV. BID ITEM NO. A49 - “SITE AC PAVEMENT”

1. METHOD OF MEASUREMENT “AC Pavement Restoration” (including UBC) shall be measured by the Square Yard and shall include furnishing and installing the 3” asphalt and 8” roadbase (UBC), including preparation of the surface and roadbase (UBC) for the pavement in the existing parking area removed as required for installation of the 42-inch HDPE Pipe.
2. BASIS OF PAYMENT Payment for “AC Pavement Restoration” (including UBC) shall be considered full compensation for all work completed under this bid item and shall be paid for at the contract unit square yard price. Work shall include all labor, equipment, and materials, including but not limited to final grading,

furnishing and installing the roadbase (UBC) and asphalt, saw cutting, compaction, and all other operations and materials required to complete the parking area pavement as herein described and as shown on the drawings be made at the contract unit lump sum bid price for completion of the work as shown on the Contract Drawings and specified herein.

WW. BID ITEM NO. 50 – “SITE LIGHTING AND SECURITY CAMERAS”

1. METHOD OF MEASUREMENT “Site Lighting and Security Cameras” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “Site Lighting and Security Cameras” shall be made at the contract lump sum bid price to install the site lighting and security cameras as shown on the Contract Drawings and Specifications. Payment shall be considered complete compensation for all labor performed and materials and equipment required. Payment shall include furnishing all labor, materials and equipment including, but not be limited to, excavation, installation of concrete bases, electrical conduits, light and/or camera poles, lights, cameras wiring; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings and Specifications.

XX. BID ITEM NO. 51 – “SITE CONTINUOUS LOUVER BLADE SCREEN WALLS”

1. METHOD OF MEASUREMENT “Site Continuous Louver Blade Screen Walls” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “Site Continuous Louver Blade Screen Walls” shall be made at the contract lump sum bid price to install the louver screen walls and gates shown on the Contract Drawings and Specifications. Payment shall be considered complete compensation for all labor performed and materials and equipment required. Payment shall include furnishing all labor, materials and equipment including, but not be limited to, excavation, concrete, posts, continuous louver blade screen walls, gate hinges, hardware; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings and Specifications.

YY. BID ITEM NO. A52 - "SITE LANDSCAPING AND IRRIGATION SYSTEM”

1. METHOD OF MEASUREMENT “Site Landscaping and Irrigation System” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “Landscaping and Irrigation System” shall be made at the contract lump sum bid price, including all required grading to match

the intent of the Contract Drawings and Specifications. Payment shall be considered complete compensation for all labor performed and materials and equipment required. Payment shall include general grading cleanup to make a smooth transition to existing structures and surrounding terrain, imported topsoil; repair of any damaged existing concrete sidewalks, curbs, or gutters; design and installation of irrigation system including connection to irrigation pump discharge pipe at the Coagulant Injection Vault, excavation, irrigation pipe and fittings, sprinklers and emitters, filter, irrigation controller, wiring; furnishing and planting all trees and shrubs, soil amendments, fertilizer; and all other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings and Specifications.

ZZ. BID ITEM NO. A53 - "RIVER DIVERSION WATER QUALITY SENSORS"

1. METHOD OF MEASUREMENT "River Diversion Water Quality Sensors" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "River Diversion Water Quality Sensors" shall be made at the contract lump sum bid price and as shown on sheet 05-X601. Payment shall be considered complete compensation for all labor performed and materials and equipment required. Payment shall include, but is not limited to, furnishing and installing the BOD/COD/DOC/TOC/NO3/UVT-254 and Turbidity water quality sensors, junction box, controller, mounting brackets, sensor holders, stainless steel chains, stainless steel bracket, conductors, cables, and other incidentals not specifically paid for in other bid items but which are shown or otherwise required to complete the installation as herein described and as shown on the Contract Drawings and Specifications.

AAA.BID ITEM NO. A54 - "ALLOWANCE FOR LABORATORY EQUIPMENT"

1. METHOD OF MEASUREMENT "Allowance for Laboratory Equipment" shall be paid for on a actual cost basis according to the amount defined in the Bid Schedule and for actual costs paid by the Contractor for equipment purchased.
2. BASIS OF PAYMENT Payment for "Allowance for Laboratory Equipment" shall be made at the actual cost required to purchase the equipment. Payment shall be considered complete compensation for all labor performed and materials and equipment required. Payment shall include purchasing the following or Engineer and Owner approved equivalent items.

Item	Design Basis Manufacturer/Model
60 L Incubator	Fisherbrand Isotemp Microbiological Incubator Catalog No: 15-103-0513
Colilert Tray Sealer	IDEXX Quanti-Tray Sealer Plus
60 L Drying Oven	Fisherbrand Isotemp General Purpose Heating and Drying Ovens Catalog No: 15-103-0503
Colilert Viewing Cabinet	IDEXX Viewing UC Cabinet
TOC Analyzer W/ Autosampler	Shimadzu TOC-L _{CSN} ASI-L Autosampler
Ion Chromatograph W/ Autosampler	ThermoScientific Dionex AS-DV
pH Meter	Hach HQ440D pH Meter Package with Electrode and Stand
Turbidity Meter	HachTL23 Series Laboratory Turbidimeters
Desktop Spectrophotometer	Hach DR3900
Full Height Lab Sample Refrigerator	Fisherbrand Isotemp General Purpose Lab Refrigerator Catalog No: FBG30RPGA
UC Reagent Lab Refrigerator	Fisherbrand Undercounter Refrigerator Catalog No: FBG505GA
UC Lab Glassware Dishwasher	Labcono 41-100-1000 FlaskScrubber Glassware Washers

Items not listed in the table but shown on the Contract Drawings and Specifications shall be included in Bid Item No. 15 above. Payment shall include any labor by the suppliers for setup and training.

BBB. BID ITEM NO. A55 - "ALLOWANCE FOR TOOLS"

1. METHOD OF MEASUREMENT "Allowance for Tools" shall be paid for on a actual cost basis according to the amount defined in the Bid Schedule and for actual costs paid by the Contractor for tools purchased.
2. BASIS OF PAYMENT Payment for "Allowance for Tools" shall be made at the actual cost required to purchase the Tools. Payment shall be considered complete compensation for all labor performed and materials and equipment required. Payment shall include purchasing the tools requested by the Owner.

CCC. BID ITEM NO. 56 – “SYSTEM TESTING AND START-UP”

1. METHOD OF MEASUREMENT “System Testing and Start-up” shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for “System Testing and Start-up” shall be considered full compensation for start-up and testing of the Water Treatment Plant as shown on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials including, but not limited to; providing personnel to assist in start-up, testing and commissioning; manufacturer services representatives; and all other incidentals required for complete system testing and start-up as specified herein and shown on the Contract Documents.

3.03 BID SCHEDULE B

A. BID ITEM NO. B1 - "MOBILIZATION / DEMOBILIZATION"

1. GENERAL This bid item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations not normally attributed to any other single bid item within this schedule. This shall include, but is not limited to, work described or enumerated in Section 01 71 13 - Mobilization. “Mobilization/Demobilization” shall not exceed 8% of the sum total of Bid Items B2 through A20.
2. METHOD OF MEASUREMENT “Mobilization / Demobilization” shall not be measured, but shall be paid for on a lump sum basis for the completion of the work as required in Section 01 71 13 - Mobilization.
3. BASIS OF PAYMENT Payment for “Mobilization / Demobilization” will be made at the contract lump sum bid price. Payments will be made in accordance with the following schedule:
 - a. When 5% of the original contract amount is earned, 40% of the amount bid for mobilization will be paid.
 - b. When 15% of the original contract amount is earned, an additional 20% for a total of 60% of the amount bid for mobilization will be paid.
 - c. When 40% of the original contract amount is earned, an additional 30% for a total of 90% of the amount bid for mobilization will be paid.
 - d. When 50% of the original contract amount is earned, an additional 10% for a total of 100% of the amount bid for mobilization will be paid.

B. BID ITEM NO. B2 - "SITE SAFETY & PEDESTRIAN AND TRAFFIC CONTROL"

1. GENERAL This bid item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations related to site and pedestrian safety, site security, and pedestrian and vehicle traffic control.
2. METHOD OF MEASUREMENT "Site Safety & Pedestrian and Traffic Control" shall not be measured, but shall be paid for on a lump sum basis for the completion of the work.
3. BASIS OF PAYMENT Payment for "Site Safety & Pedestrian and Traffic Control" will be made at the contract lump sum bid price. Payments will be made in accordance with the following schedule:
 - a. When 5% of the original contract amount is earned, 50% of the amount bid for mobilization will be paid.
 - b. When 50% of the original contract amount is earned, an additional 30% for a total of 90% of the amount bid for mobilization will be paid.
 - c. When 90% of the original contract amount is earned, an additional 20% for a total of 100% of the amount bid for mobilization will be paid.

C. BID ITEM NO. B3 - "QUALITY CONTROL AND MATERIALS TESTING"

1. GENERAL This item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations associated with Quality Control and Materials Testing. This item shall include, but is not limited to, work described or enumerated in Section 01 45 33 and Section 01 43 00.
2. METHOD OF MEASUREMENT "Quality Control and Materials Testing" shall be measured based on the percentage of work completed for the project according to the amount defined in the Bid Schedule.
3. BASIS OF PAYMENT Payment for "Quality Control and Materials Testing" will be made at the contract lump sum bid price as shown and accepted by Owner and Engineer in the Bid Schedule. Payments will be made in accordance with the following schedule:
 - a. When 10% of the original contract amount is earned, 25% of the amount bid for material testing will be paid.
 - b. When 25% of the original contract amount is earned, an additional 25% for a total of 50% of the amount bid for material testing will be paid.
 - c. When 50% of the original contract amount is earned, an additional 25% for a total of 75% of the amount bid for material testing will be paid.

- d. When 75% of the original contract amount is earned, an additional 25% for a total of 100% of the amount bid for material testing will be paid.

D. BID ITEM NO. B4 - "CONSTRUCTION SURVEYING"

1. GENERAL This item is provided to cover the Contractor's cost for general and miscellaneous responsibilities and operations associated with Construction Surveying, which shall be performed by a registered professional land surveyor.
2. METHOD OF MEASUREMENT "Construction Surveying" shall be measured based on the percentage of work completed for the project according to the amount defined in the Bid Schedule.
3. BASIS OF PAYMENT Payment for "Construction Surveying" will be made at the contract lump sum bid price as shown and accepted by Owner and Engineer in the Bid Schedule. Payments will be made in accordance with the following schedule:
 - a. When 5% of the original contract amount is earned, 75% of the amount bid for construction surveying will be paid.
 - b. When 75% of the original contract amount is earned, an additional 25% for a total of 100% of the amount bid for construction surveying will be paid.

E. BID ITEM NO. B5 - "DEVELOPMENT AND IMPLEMENTATION OF SWPPP"

1. METHOD OF MEASUREMENT "Development and Implementation of SWPPP (Storm Water Pollution Prevention Plan)" shall be paid for on a lump sum basis for preparation and implementation of the approved Plan as completed by the Contractor.
2. BASIS OF PAYMENT "Development and Implementation of the SWPPP" shall be paid for at the lump sum bid price as a percentage of work completed. Payment shall be considered full compensation for completion of an approved plan and implementation thereof. The implementation shall include installing and maintaining Best Management Practices defined in the SWPPP, and monitoring and maintaining the requirements of the SWPPP, preparation of required reports, and meeting all other requirements of the Utah Division of Water Quality.

F. BID ITEM NO. B6 – "6-INCH WATERLINE LOOP"

1. METHOD OF MEASUREMENT "6-inch Waterline Loop" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "6-inch Waterline Loop" shall be made at the contract unit lump sum bid price for installing the 6-inch waterline loop shown at Sta. 10+06 on the Contract Drawings. Payment shall be considered complete compensation for furnishing all labor, equipment, and materials necessary to remove

the existing 6" pipeline and install the new 6" waterline loop including, but not limited to, excavation, dewatering, shoring; cutting and removing and disposing of existing 6" pipeline, installing new 6" pipe and fittings, reconnecting tracer wire, thrust blocks, restraints, sand pipe zone backfill, native and/or imported trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning and flushing, disinfection and pressure testing); protection of buried utilities, potholing as needed; and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

G. BID ITEM NO. B7 – "36-INCH DUCTILE IRON TRANSMISSION PIPELINE"

1. METHOD OF MEASUREMENT "36-inch Ductile Iron Transmission Pipeline" shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the bolted sleeve coupling 2-feet outside the Valve Vault (Sta. 1+60) and continue to the flange coupling adapter connection at Sta. 10+30, continue at the flange coupling adapter connection at Sta. 11+19 and continue to the flange coupling adapter at Sta. 18+26, continue at the flange coupling adapter at Sta. 20+30 and end at the connection to the existing 36-inch pipeline near Canyon Road (Sta. 26+03).
2. BASIS OF PAYMENT Payment for "36-inch Ductile Iron Transmission Pipeline" shall be paid for at the contract unit bid price per lineal foot listed in the bidder's proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnishing and install the ductile iron pipeline to make a functional system, including, but not limited to excavation, dewatering, shoring; installing the pipe, (2) flange coupling adapters, DI long sleeve, joint restraints, tracer wire and magnetic marker tape, sand pipe zone backfill, native and/or imported trench zone backfill, compaction, removal and disposal of excess excavated material; protection of buried utilities, potholing as needed; restoration of all surface improvements (excluding asphalt and base course) including but not limited to chain link fence, concrete curb, gutter, sidewalk, driveways, sodded areas, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings. Payment for commissioning of these sections of the pipeline including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.

H. BID ITEM NO. B8 - "36-INCH DUCTILE IRON TEES AND 12" BUTTERFLY VALVES"

1. METHOD OF MEASUREMENT "36-inch Ductile Iron Tees and 12" Butterfly Valves" shall be for each 36-inch ductile iron tee and 12" butterfly valve installed by the Contractor.

2. BASIS OF PAYMENT Payment for “36-inch Ductile Iron Tee and 12” Butterfly Valve” shall be made per each 36-inch ductile iron reducing tee, 12” butterfly valve and 12” MJ plug as shown on the Contract Drawings to install complete, including all appurtenances and related work. Payment shall include all cost for furnishing, material, and labor to install the ductile iron tee, 12” butterfly valve, 12” MJ plug, and appurtenances not otherwise paid for in other bid items, including, but not limited to including cleaning, aligning, and installing the ductile iron tee, valve, plug, and restraints. Costs associated with excavations and backfilling, for the installation shall be measured and paid for with Bid Item No. B7. Payment for commissioning of these sections of the pipeline including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.
- I. **BID ITEM NO. B9 - "36-INCH DUCTILE IRON 22.5-DEG ELBOWS"**
 1. METHOD OF MEASUREMENT “36-inch Ductile Iron 22.5-deg Elbows” shall be for each 36-inch ductile iron 22.5-deg elbow installed by the Contractor.
 2. BASIS OF PAYMENT Payment for “36-inch Ductile Iron 22.5-deg Elbows” shall be made per each 36-inch ductile iron 22.5-deg elbow as shown on the Contract Drawings to install complete, including all appurtenances and related work. Payment shall include all cost for furnishing, material, and labor to install the ductile iron elbow and appurtenances not otherwise paid for in other bid items, including, but not limited to including cleaning, aligning, and installing the ductile iron elbow and restraints. Costs associated with excavations and backfilling for the elbow installation shall be measured and paid for with Bid Item No. B7. Payment for commissioning of the pipeline including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.
 - J. **BID ITEM NO. B10 - "36-INCH DUCTILE IRON 45-DEG ELBOWS"**
 1. METHOD OF MEASUREMENT “36-inch Ductile Iron 45-deg Elbows” shall be for each 36-inch ductile iron 22.5-deg elbow installed by the Contractor.
 2. BASIS OF PAYMENT Payment for “36-inch Ductile Iron 45-deg Elbows” shall be made per each 36-inch ductile iron 45-deg elbow as shown on the Contract Drawings to install complete, including all appurtenances and related work. Payment shall include all cost for furnishing, material, and labor to install the ductile iron elbow and appurtenances not otherwise paid for in other bid items, including, but not limited to including cleaning, aligning, and installing the ductile iron elbow and restraints. Costs associated with excavations and backfilling for the elbow installation shall be measured and paid for with Bid Item No. B7. Payment for commissioning of the pipeline including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.
 - K. **BID ITEM NO. B11 – “TRANSMISSION PIPELINE TRENCH OVER-EXCAVATION AND STABILIZATION”**

1. METHOD OF MEASUREMENT "Transmission Pipeline Trench Over-Excavation and Stabilization" shall be measured by the Cubic Yard for excavation and removal of soils and acceptable placement of trench bed stabilization material according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "Transmission Pipeline Trench Over-Excavation and Stabilization" shall be considered full compensation for all work completed under this bid item and shall be paid for at the contract unit cubic yard price. Payment shall be considered complete compensation for all labor, materials and equipment required for excavation and disposal of unsuitable trench bed material, dewatering, shoring, trench bed stabilization backfill, compaction, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings.

L. BID ITEM NO. B12 - "AIR VALVE VAULT"

1. METHOD OF MEASUREMENT "Air Valve Vault" shall be for each air valve vault assembly installed by the Contractor.
2. BASIS OF PAYMENT Payment for "Air Valve Vault" shall be made per each air valve vault assembly as shown on the Contract Drawings to install complete, including all valves and appurtenances and related work. Payment shall include all cost for furnishing, material and labor to install the air valve vault assembly and appurtenances not otherwise paid for in other bid items, including, but not limited to all labor, materials, and equipment for furnishing and installing the precast vault, including utility potholing, excavations, shoring, dewatering, structural fill, non-woven geotextile fabric, backfilling and compaction; manhole lids, manhole rungs; air valve and isolation valves, vent piping, vent cover, tee, and flange coupling adapters. Bid item does not include costs for associated 36-inch pipeline connections within vault, which shall be measured and paid for under Bid Item No. B7. Costs for cleaning, testing, and disinfecting the piping and valves within the vault shall also be paid for under Bid Item No. B20.

M. BID ITEM NO. B13 - "VALVE VAULT"

1. METHOD OF MEASUREMENT "Valve Vault" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "Valve Vault" shall be made at the contract lump sum bid price for the valve vault work as shown on the Contract Drawings and as specified herein. Payment shall include, but not be limited to, all labor, materials, and equipment for furnishing and installing the cast-in-place vault, including utility potholing, excavations, shoring, dewatering, structural fill, non-woven geotextile fabric, forming and curing, concrete and reinforcements, and backfilling and compaction; heavy duty access hatches, ladders; vents, air valve and isolation valves, vent stand, and associated piping; butterfly valves; pipe and fittings inside

vault and to first jointed connection outside vault; and all other related items as shown on the Contract Drawings not paid elsewhere. Costs for cleaning, testing, and disinfecting the piping and valves within the vault shall also be paid for under Bid Item No. B20.

N. BID ITEM NO. B14 - "20-INCH CONNECTION"

1. METHOD OF MEASUREMENT "20-inch Connection" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "20-inch Connection" shall be made at the contract lump sum bid price for the connection to the existing 20-inch water pipeline as shown on the Contract Drawings and as specified herein. Payment shall include, but not be limited to, all labor, materials, and equipment for furnishing and installing the 20-inch waterline connection, including utility potholing, excavations, shoring, dewatering, cutting existing pipeline, nonwoven filter fabric, backfilling and compaction; all 20-inch pipeline and fittings; tracer wire and warning tape; cleaning, disinfection (including disinfection of existing 20-inch waterline) and pressure testing; and all other related items as shown on the Contract Drawings not paid elsewhere.

O. BID ITEM NO. B15 – "36-INCH STEEL PIPELINE (STATIONS 1+24 TO 1+41)"

1. METHOD OF MEASUREMENT "36-inch Steel Pipeline (Stations 1+24 to 1+41)" shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the beginning of the transmission main at Sta. 1+24 and end with the butt strap connection outside the Valve Vault at Sta. 1+41.
2. BASIS OF PAYMENT Payment for "36-inch Steel Pipeline (Stations 1+24 to 1+41)" shall be paid for at the contract unit bid price per lineal foot listed in the bidder's proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the welded steel pipeline to make a functional system, including, but not limited to excavation, dewatering, shoring; installing the steel pipe and fittings, welding, coating and lining repairs, restraints, dual coupling harness assembly, tracer wire and magnetic marker tape, CLSM pipe zone backfill, native and/or imported trench zone backfill, compaction, removal and disposal of excess excavated material; protection of buried utilities, potholing as needed; restoration of all surface improvements including but not limited to concrete curb, gutter, sidewalk, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings. Payment for commissioning of this section of the pipeline

including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.

P. BID ITEM NO. B16– “36-INCH STEEL PIPELINE (STATIONS 10+23 TO 11+19)”

1. METHOD OF MEASUREMENT “36-inch Steel Pipeline (Stations 10+23 to 11+19)” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the beginning of the insulated flange connection at Sta. 10+23 and end with insulated flange connection at Sta. 11+19.
2. BASIS OF PAYMENT Payment for “36-inch Steel Pipeline (Stations 10+23 to 11+19)” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the welded steel pipeline to make a functional system, including, but not limited to; excavation, dewatering, shoring; installing the steel pipe and fittings, welding, coating and lining repairs, restraints, dual coupling harness assembly, tracer wire and magnetic marker tape, CLSM pipe zone backfill, native and/or imported trench zone backfill, compaction, removal and disposal of excess excavated material; protection of buried utilities, potholing as needed; restoration of all surface improvements including but not limited to concrete curb, gutter, sidewalk, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings. Payment for commissioning of this section of the pipeline including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.

Q. BID ITEM NO. B17 – “36-INCH STEEL PIPELINE (STATIONS 18+26 TO 20+30)”

1. METHOD OF MEASUREMENT “36-inch Steel Pipeline (Stations 18+26 to 20+30)” shall be measured according to the lineal foot of pipeline acceptably installed as shown on the Contract Drawings and in the Specifications. Measurement shall be along the horizontal centerline of the acceptably installed pipeline. Pipe in vertically or vertically diagonal directions will only be measured in the horizontal plane. The Contractor shall include associated cost for any such pipe as the horizontal cost per foot. Measurement shall start at the beginning of the insulated flange connection at Sta. 18+26 and end with insulated flange connection at Sta. 20+30.
2. BASIS OF PAYMENT Payment for “36-inch Steel Pipeline (Stations 18+26 to 20+30)” shall be paid for at the contract unit bid price per lineal foot listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the welded steel pipeline

to make a functional system, including, but not limited to; excavation, dewatering, shoring; installing the steel pipe and fittings, welding, coating and lining repairs, restraints, tracer wire and magnetic marker tape, CLSM pipe zone backfill, imported trench zone backfill, compaction, removal and disposal of excess excavated material, commissioning of pipeline (including cleaning and flushing, disinfection and pressure testing); protection of buried utilities, potholing as needed; grading, furnishing and installing the roadbase (UBC) and asphalt, saw cutting, compaction, and all other operations and materials required to complete the asphalt restoration; restoration of all surface improvements including but not limited to concrete curb, gutter, sidewalk, UDOT permitting and compliance, and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings. Payment for commissioning of this section of the pipeline including disinfecting and pressure testing shall be measured and paid for under Bid Item No. B20.

R. BID ITEM NO. B18 – “ASPHALT RESTORATION – FREEDOM BLVD & BYU PROPERTY”

- a. METHOD OF MEASUREMENT** “Asphalt Restoration – Freedom Blvd & BYU Property” shall be measured according to the square yardage of asphalt acceptably installed within Freedom Blvd and on BYU properties as shown on the Contract Drawings and in the Specifications.
- b. BASIS OF PAYMENT** Payment for “Asphalt Restoration – Freedom Blvd & BYU Property” shall be paid for at the contract unit bid price per square yardage listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the 5-inch thick asphalt and 8-inch thick base course, including but not limited to; saw cutting, addition asphalt removals beyond the trench excavations, grading, furnishing and installing the roadbase (UBC) and asphalt, compaction, and all other operations and materials required to complete the asphalt restoration as shown on the Contract Drawings.

S. BID ITEM NO. B19 – “ASPHALT RESTORATION – UNIVERSITY AVE”

- 1. METHOD OF MEASUREMENT** “Asphalt Restoration – University Ave” shall be measured according to the square yardage of asphalt acceptably installed within University Ave properties as shown on the Contract Drawings and in the Specifications.
- 2. BASIS OF PAYMENT** Payment for “Asphalt Restoration – University Ave” shall be paid for at the contract unit bid price per square yardage listed in the bidder’s proposal and shall be considered complete compensation for all labor, equipment, and materials necessary to furnish and install the 7-inch thick asphalt and 8-inch thick base course trench patch and the 2-inch thick mill and asphalt overlay, including but not limited to milling, saw cutting, grading, furnishing and installing the roadbase (UBC) and asphalt, micro-surfacing (if applicable), compaction, and

all other operations and materials required to complete the asphalt restoration as shown on the Contract Drawings per UDOT standards and acceptance. At CONTRACTOR'S option UDOT asphalt restoration shall be SMA or HMA with Micro-Surfacing.

T. BID ITEM NO. B20 - "36-INCH TRANSMISSION MAIN COMMISSIONING"

1. METHOD OF MEASUREMENT "36-inch Transmission Main Commissioning" shall be paid for on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
2. BASIS OF PAYMENT Payment for "36-inch Transmission Main Commissioning" shall be made at the contract lump sum bid price for the commissioning the 36-inch transmission main from Sta. 1+24 to Sta. 26+03 as shown on the Contract Drawings and as specified herein. Payment shall be considered complete compensation for all labor, equipment, and materials necessary to flush, clean, disinfect, and testing the pipeline to commission to as a functional system, including, but not limited to flushing, cleaning, disinfecting, pressure testing, repairs and retesting (if required) and all other operations and materials required to complete this portion of the work as herein described and as shown on the Contract Drawings. Payment shall also include furnishing, installing, and removing temporary blow-offs, valves, blind flanges, plugs, and fittings required to flush, test, and disinfect new pipeline.

3.04 BID SCHEDULE C

A. ADDITIVE/DEDUCTIVE BID ITEM NO. C1 – "BECK ELECTRIC ACTUATORS"

1. GENERAL This bid item is included to allow the Owner the opportunity to change from another electric actuator supplier to the Beck electric actuators. If Beck electric actuators are already included in the Contractors bid items in Bid Schedule A, then the amount listed in this Bid Item should be zero (no cost).
2. METHOD OF MEASUREMENT "Beck Electric Actuators" shall be measured on a lump sum basis according to the amount defined in the Bid Schedule and as completed by the Contractor.
3. BASIS OF PAYMENT Payment for "Beck Electric Actuators" shall be made at the contract shall be made at the contract lump sum bid price when approved by OWNER. Payment shall be considered complete compensation for all labor, equipment and materials, to replace all electric actuators (excluding actuators provided with the UF Membrane Filtration Units – Bid Item No. A11) in Bid Schedule A with Beck electric actuators and other incidental items to complete the installation as herein described and as shown on the Contract Drawings and Specifications.

3.05 BID SCHEDULE D

A. DEDUCTIVE ALTERNATE BID ITEM NO. D1 – "20 MGD CAPACITY PLANT"

1. GENERAL This item is provided to cover a reduction in Bid Schedule A Base Bid cost to change the treatment capacity of the WTP from 30 MGD to 20 MGD. Owner will evaluate and accept this item before the Notice of Award.
2. BASIS OF BID The lump sum amount provided for “20 MGD Capacity Plant” shall be calculated as follows:
 - a. The following equipment shall be deducted as part of this bid alternate. See contract drawings sheets “-D1” for locations of equipment to be excluded as part of this deduction.
 - (1) 10 Water Treatment Facility
 - (a) UF Feed Pump 10: PMP-0210-1
 - (b) UF Feed Pump 11: PMP-0211-1
 - (c) UF Feed Pump 12: PMP-0212-1
 - (d) UF Feed Pump 13: PMP-0213-1
 - (e) UF Strainer 10: STR-0210-2
 - (f) UF Strainer 11: STR-0211-2
 - (g) UF Strainer 12: STR-0212-2
 - (h) UF Strainer 13: STR-0213-2
 - (i) UF Skid 10: FLT-0203-10
 - (j) UF Skid 11: FLT-0203-11
 - (k) UF Skid 12: FLT-0203-12
 - (l) UF Skid 13: FLT-0203-13
 - (m) Backwash Recycle Pump 3: PMP-0251-3
 - (n) UF Backwash Pump 3: PMP-0241-3
 - (o) Compressor 3: CM-0231-3
 - (p) Ozone Generator 2: GEN-0308-2
 - (2) 20 Clearwell & Pump Station
 - (a) High Service Pump 5: PMP-0415-1

(b) Surge Tank 2: TNK-0417-2

b. Description of deduction at 10 Water Treatment Facility

- (1) Provide cost deduction to remove noted UF Feed Vertical Turbine Pumps including suction and discharge piping, expansion joints, all valves, expansion joint, pressure gauges, pressure switches, electrical and signal cabling, local disconnects, appurtenances, and motors. Provide and install blind flanges as needed on suction headers to facilitate installation of pump piping in the future. Pump cans shall be provided and installed. Install blind flanges on pump can suction connections and steel plates on the top of the cans. Conduit (without cabling) shall be provided and installed for future pump installation.
- (2) Provide cost deduction to remove noted UF Strainers including strainer hosing inlet and outlet piping and fittings, all valves and actuators, motors, pressure gauges and transmitters, electrical and signal cabling, local disconnects, and appurtenances. Install 3" floor penetrations at each strainer location for future backwash waste line. Conduit (without cabling) shall be provided and installed for future strainer installation.
- (3) Provide cost deduction to remove noted UF Membrane Filtration Skids including all piping and tubing and fittings, support frames, all valves and actuators, membrane modules, all analytical instruments, remote I/O panels, and appurtenances. Install appropriately sized floor penetrations for all piping connections from below and provide a steel plate at the penetration. Install appropriately sized blind flanges on the header pipes for the filtrate, backwash outlet, backwash inlet, air inlet, all chemical cleaning connections, and purge lines.
- (4) Provide cost deduction to remove piping and fittings to/from equipment to be removed, see Contract Drawings "-D1" for locations. For removed piping install blind flanges to allow for future installation of piping. For floor penetrations $\geq 3"$, install floor penetrations w/ steel cover plates for future installation.
- (5) Provide a cost deduction for removing Ozone Generator 2 from the Ozone Scope of Supply and associated piping, valves, instrumentation, and appurtenances. Provide space in the Ozone room for equipment in the future. Conduit (without cabling) shall be provided and installed for future generator installation.
- (6) Provide cost deduction to remove Backwash Recycle Pump 3 including suction and discharge piping and fittings, motor, flow control valve, isolation valves, pressure switch, expansion joint. Install a blind flange on the tee at Backwash Recycle Pump 3 suction and discharge. Conduit

(without cabling) shall be provided and installed for future pump installation.

- (7) Provide a deduction for removing 10-MCC-3 including all drives and associated electrical equipment. Provide space in the future for an additional MCC. Remove conductors but provide conduit for electrical equipment.
 - (8) Provide a reduction for removing Air Compressor 3 from the UF Manufacturer scope of supply including compressor, discharge piping, valves, instrumentation, and appurtenances. Conduit (without cabling) shall be provided and installed for future compressor installation.
 - (9) Provide cost deduction for removing items at the Water Treatment Facility including other incidentals not noted above no longer required for remove the noted equipment.
- c. Description of deduction at 20 Clearwell & Pump Station
- (1) Provide cost deduction to remove High Service Vertical Turbine Pump No. 5 including motor, and discharge head. Pump can and all suction piping shall be provided and installed. Install blind flange on the pump can. Remove all discharge pipe and valves and install blind flange on the main discharge header connection. Also remove Surge Tank No. 2 and butterfly valve (VLV-0417-2A) and replace with a blind flange.
 - (2) Provide cost deduction for removing items at the High Service Pump Station including VFDs, wiring, piping, valves, and other incidentals no longer required for removed High Service Vertical Turbine Pumps.
- d. Description of deduction for Electrical, Instrumentation and Control:
- (1) 10-MCC-3 shall be removed as part of the deduct including power and control cabling. All conduit shall be installed along with housekeeping pad for MCC.
 - (2) Remove connections for Ozone Generator 2 including disconnect, power and control cabling. All conduit shall be installed along with transformer rack.
 - (3) Remove connections for High Service Pump 5 including VFD, power and control cabling. All conduit shall be installed.
- e. Provide cost deductions summarized as follows:

Item	Qty	Unit	Unit Bid Amount	Total Bid Amount
UF Membrane Filtration Units (UF Skids 10-13)	4	EA	\$	\$
UF Feed Vertical Turbine Pumps (UF Feed Pumps 10-13)	4	EA	\$	\$
High Service Vertical Turbine Pumps 5	1	EA	\$	\$
Water Treatment Plant Facility	1	LS		\$
High Service Pump Station	1	LS		\$
Bid Item D1 Total Deduction				\$

ATTACHMENT A: NON-BABA COMPLIANT BID ALTERNATE SCHEDULES

SCHEDULE ALT-A – MAIN PLANT SITE BID

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
A1	Mobilization / Demobilization	1	LS		\$
A2	Site Safety & Pedestrian and Traffic Control	1	LS		\$
A3	Quality Control and Materials Testing	1	LS		\$
A4	Construction Surveying	1	LS		\$
A5	Development and Implementation of SWPPP	1	LS		\$
A6	Demolition of Existing Structures	1	LS		\$
A7	Site Clearing, Grubbing, and Stripping	1	LS		\$
A8	Site Excavation and Shoring	1	LS		\$
A9	Ground Improvements	1	LS		\$
A10	Site Dewatering	1	LS		\$
A11	UF Membrane Filtration Units	13	EA	\$	\$
A12	UF Feed Vertical Turbine Pumps	13	EA	\$	\$
A13	High Service Vertical Turbine Pumps (10 MGD)	3	EA	\$	\$
A14	High Service Vertical Turbine Pumps (5 MGD)	2	EA	\$	\$
A15	Water Treatment Plant Facility (Plant Area 10)	1	LS		\$
A16	2 MG Clearwell (Plant Area 20)	1	LS		\$
A17	High Service Pump Station (Plant Area 20)	1	LS		\$
A18	Concrete Diversion Box	1	LS		\$
A19	Coagulant Injection Vault	1	LS		\$
A20	Site Storm Drain Pipe	551	LF	\$	\$
A21	42-inch RCP Overflow Pipe	52	LF	\$	\$
A22	6-inch DI Pipe, Fire Hydrant, and Connection	1	LF	\$	\$
A23	6-inch DI Fire Service Connection	1	LF	\$	\$
A24	12-inch PVC Sanitary Sewer Connection	1	LF	\$	\$
A25	42-inch HDPE Raw Water Pipeline	168	LF	\$	\$
A26	42-inch RCP Mill Race Pipeline	545	LF	\$	\$
A27	42-inch Steel Raw Water Pipe	126	LF	\$	\$
A28	12-inch Steel MW Pipe	72	LF	\$	\$
A29	12-inch Steel RW Pipe	77	LF	\$	\$
A30	10-inch Steel BRW Pipe	93	LF	\$	\$
A31	42-inch Steel Ozonated Water Pipe	99	LF	\$	\$
A32	42-inch Steel Finished Water Pipe	163	LF	\$	\$
A33	Chain Link Fence and Swing Gates	1	LS	\$	\$
A34	2-inch PE Water Service Connection and Pipe	1	LS		\$
A35	4-inch PE Natural Gas Pipe (Dominion Energy)	493	LF	\$	\$
A36	Site PE Natural Gas Piping	1	LS		\$
A37	Chemical Solution & Sampling Piping and Vaults	1	LS		\$
A38	6-inch PVC Miscellaneous Storm Drain Piping	1	LS		\$
A39	Concrete Retaining Wall and CMU Screen Wall	1	LS	\$	\$
A40	Large Block Retaining Wall	1	LS	\$	\$
A41	Concrete Generator Pads and Slab-on-Grade	1	LS	\$	\$
A42	1,000kW Natural Gas Generators	3	EA	\$	\$
A43	Drain Vault and Emergency Overflow Box	1	LS		\$

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
A44	Site Backfill, Grading, and Compaction	1	LS		\$
A45	Site Concrete Entrances	2	EA	\$	\$
A46	Freedom Blvd Concrete Sidewalk	397	LF	\$	\$
A47	Site Concrete Curb and Gutter	1,060	LF	\$	\$
A48	Site Concrete Slab-on-Grade	9,161	SF	\$	\$
A49	Site AC Pavement	3,631	SY	\$	\$
A50	Site Lighting and Security Cameras	1	LS		\$
A51	Site Continuous Louver Blade Screen Walls	1	LS		\$
A52	Site Landscaping and Irrigation System	1	LS		\$
A53	River Diversion Water Quality Sensors	1	LS		\$
A54	Allowance for Laboratory Equipment	1	AC		\$250,000
A55	Allowance for Tools	1	AC		\$20,000
A56	System Testing and Start-up	1	LS		\$
ALTERNATE BID SCHEDULE A BID TOTAL				\$	
Cost Contingency for Holding Bid up to 120 days				\$	

SCHEDULE ALT-B – 36-INCH TRANSMISSION PIPELINE BID

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
B1	Mobilization / Demobilization	1	LS		\$
B2	Site Safety & Pedestrian and Traffic Control	1	LS		\$
B3	Quality Control and Materials Testing	1	LS		\$
B4	Construction Surveying	1	LS		\$
B5	Development and Implementation of SWPPP	1	LS		\$
B6	6-inch Waterline Loop	1	LS		\$
B7	36-inch Ductile Iron Transmission Pipeline	2,143	LF	\$	\$
B8	36-inch Ductile Iron Tees and 12" Butterfly Valves	2	EA	\$	\$
B9	36-inch Ductile Iron 22.5-deg Elbows	4	EA	\$	\$
B10	36-inch Ductile Iron 45-deg Elbows	4	EA	\$	\$
B11	Transmission Pipeline Trench Over-Excavation & Stabilization	55	CY	\$	\$
B12	Air Valve Vault	2	EA	\$	\$
B13	Valve Vault	1	LS		\$
B14	20-inch Connection	1	LS		\$
B15	36-inch Steel Pipeline (Stations 1+24 to 1+41)	17	LF	\$	\$
B16	36-inch Steel Pipeline (Stations 10+23 to 11+19)	96	LF	\$	\$
B17	36-inch Steel Pipeline (Stations 18+26 to 20+30)	204	LF	\$	\$
B18	Asphalt Restoration - Freedom Blvd & BYU Property	4,075	SY	\$	\$
B19	Asphalt Restoration - University Avenue	295	SY	\$	\$
B20	36" Transmission Main Commissioning	1	LS		
ALTERNATE BID SCHEDULE B BID TOTAL				\$	
Cost Contingency for Holding Bid up to 120 days				\$	

SCHEDULE ALT-A+B

Total of Bid Schedule ALT-A and Bid Schedule ALT-B = Total Bid Price (not including cost contingency for holding bid)	\$
(In words)	

SCHEDULE ALT-C – ADDITIVE BID ITEMS

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
C1	Beck Electric Actuators	1	LS		\$
ALTERNATE BID SCHEDULE C – ADDITIVE BID ITEMS BID TOTAL				\$	

SCHEDULE ALT-D – DEDUCTIVE ALTERNATE

	Description	Qty	Unit	Unit Bid Amount	Total Bid Amount
D1	20 MGD Capacity Plant	1	LS		\$
ALTERNATE BID SCHEDULE D – DEDUCTIVE ALTERNATE BID TOTAL				\$	

END OF SECTION

SECTION 00 43 36

PROPOSED SUBCONTRACTOR FORM

PART 1 - GENERAL

1.01 BIDDER

- A. Name: _____
- B. Address: _____

- C. Telephone Number: _____

1.02 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202.

PART 2 - REPORT

2.01 SUBCONTRACTOR AND SUPPLIER REPORT

- A. Failure of the Bidder to specify a Subcontractor for any portion of the Work constitutes an agreement by the Bidder that the Bidder is fully qualified to perform that portion, and that Bidder shall perform that portion.
- B. Bidder will be fully responsible to Owner for the acts and omissions of Subcontractors and Suppliers and of persons either directly or indirectly employed by them, as Bidder is for the acts and omissions of persons employed by Bidder directly.
- C. Nothing contained in the Contract Documents shall create any contractual relationship between any Subcontractor or Supplier and the Owner. Bidder agrees each subcontract with Bidder's Subcontractor will disclaim any third party or direct relationship between Owner and any Subcontractor or Supplier.
- D. The names and addresses of the Subcontractors and Suppliers who will work under the terms of the Contract Documents and the estimated dollar amount of each subcontract (provide listed subcontractors and suppliers and those to provide services in excess of 2 percent of the Bid sum) are set forth as follows.

Table 1 – SCHEDULE A - BASE BID

SUBCONTRACTORS		
Name and Address	Nature and Extent of Work to be Sublet	Amount
1.	Electrical	
2.	Mechanical HVAC	
3.	Ground Improvements	
4.		
5.		
6.		
SUPPLIERS		
Name and Address	Nature and Extent of Work to be Sublet	Amount
1.	UF Membrane Systems	
2.	Ozone Generation System	
3.	Vertical Turbine Pumps and Motors	
4.	Surge Tanks	
5.		
6.		
7.		

PART 3 - EXECUTION

3.01 EFFECTIVE DATE

- A. Bidder executes this Subcontractor and Supplier report and declares it to be a supplement to the Bid and in effect as of _____, _____.

3.02 BIDDER'S SUBSCRIPTION

- A. Bidder's signature: _____
- B. Please print Bidder's name here: _____
- C. Title: _____

END OF SECTION

SECTION 00 43 38
BIDDER STATUS FORM

PART 1 - GENERAL

1.01 BIDDER

- A. Name: _____
- B. Address: _____

- C. Telephone Number: _____
- D. Federal Tax ID Number: _____

1.02 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202.

PART 2 - REPORT

2.01 BIDDER STATUS REPORT

- A. Bidder affirms the following information is true and correct.
1. Number of employees: _____
 2. Bidder's firm is: (check the following as applicable)
 - ☐ Independently owned and operated.
 - ☐ An affiliate of*
 - ☐ A subsidiary of*
 - ☐ A division of*
 - ☐ A business with gross revenue in excess of \$ _____
 - ☐ A business with gross revenue below \$ _____

* PARENT COMPANY:

Name: _____

Address: _____

Telephone Number: _____

Facsimile Number: _____

PART 3 - EXECUTION

3.01 EFFECTIVE DATE

- A. Bidder executes this status report and declares it to be a supplement to the Bid and in effect as of _____, _____.

3.02 BIDDER'S SUBSCRIPTION

A. Bidder's Signature: _____

B. Please print Bidder's name here: _____

C. Title: _____

END OF SECTION

SECTION 00 45 15

FEDERAL REQUIREMENTS

This contract is subject to the requirements and regulations governing projects receiving Federal Funding. The funds for this project include a FEMA Building Resilience Infrastructure Communities (BRIC) Grant and therefore FEMA grant contract provisions outlined in the link here (https://www.fema.gov/sites/default/files/documents/fema_contract-provisions-guide_6-14-2021.pdf) and provided for reference as follows:

1.01 EQUAL EMPLOYMENT OPPORTUNITY

During the performance of this contract, the contractor agrees as follows:

- (1) The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, sexual orientation, gender identity, or national origin. The contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment without regard to their race, color, religion, sex, sexual orientation, gender identity, or national origin. Such action shall include, but not be limited to the following:

Employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided setting forth the provisions of this nondiscrimination clause.

- (2) The contractor will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin.
- (3) The contractor will not discharge or in any other manner discriminate against any employee or applicant for employment because such employee or applicant has inquired about, discussed, or disclosed the compensation of the employee or applicant or another employee or applicant. This provision shall not apply to instances in which an employee who has access to the compensation information of other employees or applicants as a part of such employee's essential job functions discloses the compensation of such other employees or applicants to individuals who do not otherwise have access to such information, unless such disclosure is in response to a formal complaint or charge, in furtherance of an investigation, proceeding, hearing, or action, including an investigation conducted by the employer, or is consistent with the contractor's legal duty to furnish information.
- (4) The contractor will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice to be provided advising the said labor union or workers' representatives of the contractor's

commitments under this section, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

- (5) The contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.
- (6) The contractor will furnish all information and reports required by Executive Order 11246 of September 24, 1965, and by rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the administering agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.
- (7) In the event of the contractor's noncompliance with the nondiscrimination clauses of this contract or with any of the said rules, regulations, or orders, this contract may be canceled, terminated, or suspended in whole or in part and the contractor may be declared ineligible for further Government contracts or federally assisted construction contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.
- (8) The contractor will include the portion of the sentence immediately preceding paragraph (1) and the provisions of paragraphs (1) through (8) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The contractor will take such action with respect to any subcontract or purchase order as the administering agency may direct as a means of enforcing such provisions, including sanctions for noncompliance:

Provided, however, that in the event a contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the administering agency, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

The applicant further agrees that it will be bound by the above equal opportunity clause with respect to its own employment practices when it participates in federally assisted construction work: Provided, that if the applicant so participating is a state or local government, the above equal opportunity clause is not applicable to any agency, instrumentality or subdivision of such government which does not participate in work on or under the contract.

The applicant agrees that it will assist and cooperate actively with the administering agency and the Secretary of Labor in obtaining the compliance of contractors and subcontractors with the equal opportunity clause and the rules, regulations, and relevant orders of the Secretary of Labor, that it will furnish the administering agency and the

Secretary of Labor such information as they may require for the supervision of such compliance, and that it will otherwise assist the administering agency in the discharge of the agency's primary responsibility for securing compliance.

The applicant further agrees that it will refrain from entering into any contract or contract modification subject to Executive Order 11246 of September 24, 1965, with a contractor debarred from, or who has not demonstrated eligibility for, Government contracts and federally assisted construction contracts pursuant to the Executive Order and will carry out such sanctions and penalties for violation of the equal opportunity clause as may be imposed upon contractors and subcontractors by the administering agency or the Secretary of Labor pursuant to Part II, Subpart D of the Executive Order. In addition, the applicant agrees that if it fails or refuses to comply with these undertakings, the administering agency may take any or all of the following actions: Cancel, terminate, or suspend in whole or in part this grant (contract, loan, insurance, guarantee); refrain from extending any further assistance to the applicant under the program with respect to which the failure or refund occurred until satisfactory assurance of future compliance has been received from such applicant; and refer the case to the Department of Justice for appropriate legal proceedings.

1.02 CONTRACT WORK HOURS AND SAFETY STANDARDS ACT **Compliance with the Contract Work Hours and Safety Standards Act.**

(1) Overtime requirements. No contractor or subcontractor contracting for any part of the contract work which may require or involve the employment of laborers or mechanics shall require or permit any such laborer or mechanic in any workweek in which he or she is employed on such work to work in excess of forty hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times the basic rate of pay for all hours worked in excess of forty hours in such workweek.

(2) Violation; liability for unpaid wages; liquidated damages. In the event of any violation of the clause set forth in paragraph (b)(1) of this section the contractor and any subcontractor responsible therefor shall be liable for the unpaid wages. In addition, such contractor and subcontractor shall be liable to the United States (in the case of work done under contract for the District of Columbia or a territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic, including watchmen and guards, employed in violation of the clause set forth in paragraph (b)(1) of this section, in the sum of \$27 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty hours without payment of the overtime wages required by the clause set forth in paragraph (b)(1) of this section.

(3) Withholding for unpaid wages and liquidated damages. The City of Provo shall upon its own action or upon written request of an authorized representative of the Department of Labor withhold or cause to be withheld, from any moneys payable on account of work performed by

the contractor or subcontractor under any such contract or any other federal contract with the same prime contractor, or any other federally-assisted contract subject to the Contract Work Hours and Safety Standards Act, which is held by the same prime contractor, such sums as may be determined to be necessary to satisfy any liabilities of such contractor or subcontractor for unpaid wages and liquidated damages as provided in the clause set forth in paragraph (b)(2) of this section.

(4) Subcontracts. The contractor or subcontractor shall insert in any subcontracts the clauses set forth in paragraph (b)(1) through (4) of this section and also a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime contractor shall be responsible for compliance by any subcontractor or lower tier subcontractor with the clauses set forth in paragraphs (b)(1) through (4) of this section.

1.03 FURTHER COMPLIANCE WITH THE CONTRACT WORK HOURS AND SAFETY STANDARDS ACT.

(1) The contractor or subcontractor shall maintain payrolls and basic payroll records during the course of the work and shall preserve them for a period of three years from the completion of the contract for all laborers and mechanics, including guards and watchmen, working on the contract. Such records shall contain the name and address of each such employee, social security number, correct classifications, hourly rates of wages paid, daily and weekly number of hours worked, deductions made, and actual wages paid.

(2) Records to be maintained under this provision shall be made available by the contractor or subcontractor for inspection, copying, or transcription by authorized representatives of the Department of Homeland Security, the Federal Emergency Management Agency, and the Department of Labor, and the contractor or subcontractor will permit such representatives to interview employees during working hours on the job.

1.04 CLEAN AIR ACT AND FEDERAL WATER POLLUTION CONTROL ACT **Compliance with Clean Air Act**

The contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. § 7401 et seq.

The contractor agrees to report each violation to the (insert name of non-federal entity entering into the contract) and understands and agrees that the (insert name of the non-federal entity entering into the contract) will, in turn, report each violation as required to assure notification to the Federal Emergency Management Agency (FEMA), and the appropriate Environmental Protection Agency Regional Office.

The contractor agrees to include these requirements in each subcontract exceeding \$150,000 financed in whole or in part with federal assistance provided by FEMA.

Compliance with Federal Water Pollution Control Act

The contractor agrees to comply with all applicable standards, orders, or regulations issued pursuant to the federal Water Pollution Control Act, as amended, 33 U.S.C. § 1251 et seq.

The contractor agrees to report each violation to the (insert name of the non-federal entity entering into the contract) and understands and agrees that the (insert name of the non-federal entity entering into the contract) will, in turn, report each violation as required to assure notification to the (insert name of the pass-through entity, if applicable), Federal Emergency Management Agency (FEMA), and the appropriate Environmental Protection Agency Regional Office.

The contractor agrees to include these requirements in each subcontract exceeding \$150,000 financed in whole or in part with federal assistance provided by FEMA.

1.05 DEBARMENT AND SUSPENSION

Suspension and Debarment

This contract is a covered transaction for purposes of 2 C.F.R. Part 180 and 2 C.F.R. Part 3000. As such, the contractor is required to verify that none of the contractor's principals (defined at 2 C.F.R. § 180.995) or its affiliates (defined at 2 C.F.R. § 180.905) are excluded (defined at 2 C.F.R. § 180.940) or disqualified (defined at 2 C.F.R. § 180.935).

The contractor must comply with 2 C.F.R. Part 180, subpart C and 2 C.F.R. Part 3000, subpart C, and must include a requirement to comply with these regulations in any lower tier covered transaction it enters into.

This certification is a material representation of fact relied upon by (insert name of recipient/subrecipient/applicant). If it is later determined that the contractor did not comply with 2 C.F.R. Part 180, subpart C and 2 C.F.R. Part 3000, subpart C, in addition to remedies available to (insert name of recipient/subrecipient/applicant), the federal government may pursue available remedies, including but not limited to suspension and/or debarment.

The bidder or proposer agrees to comply with the requirements of 2 C.F.R. Part 180, subpart C and 2 C.F.R. Part 3000, subpart C while this offer is valid and throughout the period of any contract that may arise from this offer. The bidder or proposer further agrees to include a provision requiring such compliance in its lower tier covered transactions.

1.06 BYRD ANTI-LOBBYING AMENDMENT

Byrd Anti-Lobbying Amendment, 31 U.S.C. § 1352 (as amended)

Contractors who apply or bid for an award of more than \$100,000 shall file the required certification. Each tier certifies to the tier above that it will not and has not used federally appropriated funds to pay any person or organization for influencing or attempting to influence

an officer or employee of any agency, a Member of Congress, officer or employee of Congress, or an employee of a Member of Congress in connection with obtaining any federal contract, grant, or any other award covered by 31 U.S.C. § 1352. Each tier shall also disclose any lobbying with non-federal funds that takes place in connection with obtaining any federal award. Such disclosures are forwarded from tier to tier up to the recipient who in turn will forward the certification(s) to the federal awarding agency.

1.07 REQUIRED CERTIFICATION LANGUAGE

Contractor shall sign and submit the following certification for each bid or offer exceeding \$100,000

APPENDIX A, 44 C.F.R. PART 18 – CERTIFICATION REGARDING LOBBYING

Certification for Contracts, Grants, Loans, and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any federal grant, the making of any federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any federal contract, grant, loan, or cooperative agreement.

If any funds other than federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, “Disclosure Form to Report Lobbying,” in accordance with its instructions.

The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S.C. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

1.08 PROCUREMENT OF RECOVERED MATERIALS

In the performance of this contract, the Contractor shall make maximum use of products containing recovered materials that are EPA-designated items unless the product cannot be acquired—

Competitively within a timeframe providing for compliance with the contract performance schedule;

Meeting contract performance requirements; or

At a reasonable price.

Information about this requirement, along with the list of EPA-designated items, is available at EPA's Comprehensive Procurement Guidelines webpage:

<https://www.epa.gov/smm/comprehensive-procurement-guideline-cpg-program>.

The Contractor also agrees to comply with all other applicable requirements of Section 6002 of the Solid Waste Disposal Act.

1.09 PROHIBITION ON CONTRACTING FOR COVERED TELECOMMUNICATIONS EQUIPMENT OR SERVICES

Prohibition on Contracting for Covered Telecommunications Equipment or Services

(a) *Definitions.* As used in this clause, the terms backhaul; covered foreign country; covered telecommunications equipment or services; interconnection arrangements; roaming; substantial or essential component; and telecommunications equipment or services have the meaning as defined in FEMA Policy 405-143-1, Prohibitions on Expending FEMA Award Funds for Covered Telecommunications Equipment or Services, as used in this clause—

(b) *Prohibitions.*

- (1) Section 889(b) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019, Pub. L. No. 115-232, and 2 C.F.R. § 200.216 prohibit the head of an executive agency on or after Aug. 13, 2020, from obligating or expending grant, cooperative agreement, loan, or loan guarantee funds on certain telecommunications products or from certain entities for national security reasons.
- (2) Unless an exception in paragraph (c) of this clause applies, the contractor and its subcontractors may not use grant, cooperative agreement, loan, or loan guarantee funds from the Federal Emergency Management Agency to:
 - i. Procure or obtain any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology of any system;
 - ii. Enter into, extend, or renew a contract to procure or obtain any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology of any system;

- iii. Enter into, extend, or renew contracts with entities that use covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system; or
- iv. Provide, as part of its performance of this contract, subcontract, or other contractual instrument, any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system.

(c) Exceptions.

- (1) This clause does not prohibit contractors from providing—
 - i. A service that connects to the facilities of a third-party, such as backhaul, roaming, or interconnection arrangements; or
 - ii. Telecommunications equipment that cannot route or redirect user data traffic or permit visibility into any user data or packets that such equipment transmits or otherwise handles.
- (2) By necessary implication and regulation, the prohibitions also do not apply to:
 - i. Covered telecommunications equipment or services that:
 - i. Are not used as a substantial or essential component of any system; and
 - ii. Are not used as critical technology of any system.
 - ii. Other telecommunications equipment or services that are not considered covered telecommunications equipment or services.

(d) Reporting requirement.

- (1) In the event the contractor identifies covered telecommunications equipment or services used as a substantial or essential component of any system, or as critical technology as part of any system, during contract performance, or the contractor is notified of such by a subcontractor at any tier or by any other source, the contractor shall report the information in paragraph (d)(2) of this clause to the recipient or subrecipient, unless elsewhere in this contract are established procedures for reporting the information.
- (2) The Contractor shall report the following information pursuant to paragraph (d)(1) of this clause:
 - i. Within one business day from the date of such identification or notification: The contract number; the order number(s), if applicable; supplier name; supplier unique entity identifier (if known); supplier Commercial and Government Entity (CAGE) code (if known); brand; model number (original equipment manufacturer number, manufacturer part number, or wholesaler number); item description; and any readily available information about mitigation actions undertaken or recommended.
 - ii. Within 10 business days of submitting the information in paragraph (d)(2)(i) of this clause: Any further available information about mitigation actions undertaken or recommended. In addition, the contractor shall describe the efforts it undertook to prevent use or submission of covered telecommunications equipment or

services, and any additional efforts that will be incorporated to prevent future use or submission of covered telecommunications equipment or services.

(e) *Subcontracts*. The Contractor shall insert the substance of this clause, including this paragraph (e), in all subcontracts and other contractual instruments.

1.10 DOMESTIC PREFERENCES FOR PROCUREMENTS

Domestic Preference for Procurements

As appropriate, and to the extent consistent with law, the contractor should, to the greatest extent practicable, provide a preference for the purchase, acquisition, or use of goods, products, or materials produced in the United States. This includes, but is not limited to iron, aluminum, steel, cement, and other manufactured products.

For purposes of this clause:

Produced in the United States means, for iron and steel products, that all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States.

Manufactured products mean items and construction materials composed in whole or in part of non-ferrous metals such as aluminum; plastics and polymer-based products such as polyvinyl chloride pipe; aggregates such as concrete; glass, including optical fiber; and lumber.

1.11 BUILD AMERICA BUY AMERICA ACT PROCUREMENT PREFERENCE

As required by Section 70914 of the Bipartisan Infrastructure Law (also known as the Infrastructure Investment and Jobs Act), P.L. 117-58, on or after May 14, 2022, none of the funds under a federal award that are part of Federal financial assistance program for infrastructure may be obligated for a project unless all of the iron, steel, manufactured products, and construction materials used in the project are produced in the United States, unless subject to an approved waiver. The requirements of this section must be included in all subawards, including all contracts and purchase orders for work or products under this program.

Recipients of an award of Federal financial assistance are hereby notified that none of the funds provided under this award may be used for a project for infrastructure unless:

1. All iron and steel used in the project are produced in the United States--this means all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States;
2. All manufactured products used in the project are produced in the United States—this means the manufactured product was manufactured in the United States; and the cost of the components of the manufactured product that are mined, produced, or manufactured in the United States is greater than 55 percent of the total cost of all components of the manufactured product, unless another standard for determining the minimum amount of domestic content of the manufactured product has been established under applicable law or regulation; and

3. All construction materials are manufactured in the United States—this means that all manufacturing processes for the construction material occurred in the United States.

The Buy America preference only applies to articles, materials, and supplies that are consumed in, incorporated into, or affixed to an infrastructure project. As such, it does not apply to tools, equipment, and supplies, such as temporary scaffolding, brought to the construction site and removed at or before the completion of the infrastructure project. Nor does a Buy America preference apply to equipment and furnishings, such as movable chairs, desks, and portable computer equipment, that are used at or within the finished infrastructure project, but are not an integral part of the structure or permanently affixed to the infrastructure project.

1.12 ACCESS TO RECORDS

The Contractor agrees to provide the City of Provo, the FEMA Administrator, the Comptroller General of the United States, or any of their authorized representatives access to any books, documents, papers, and records of the Contractor which are directly pertinent to this contract for the purposes of making audits, examinations, excerpts, and transcriptions.

The Contractor agrees to permit any of the foregoing parties to reproduce by any means whatsoever or to copy excerpts and transcriptions as reasonably needed.

The Contractor agrees to provide the FEMA Administrator or his authorized representatives access to construction or other work sites pertaining to the work being completed under the contract.

1.13 DHS SEAL, LOGO, AND FLAGS

The contractor shall not use the DHS seal(s), logos, crests, or reproductions of flags or likenesses of DHS agency officials without specific FEMA pre-approval. The contractor shall include this provision in any subcontracts.

1.14 COMPLIANCE WITH FEDERAL LAW, REGULATIONS AND EXECUTIVE ORDERS

This is an acknowledgement that FEMA financial assistance will be used to fund all or a portion of the contract. The contractor will comply with all applicable federal law, regulations, executive orders, FEMA policies, procedures, and directives.

1.15 NO OBLIGATION BY FEDERAL GOVERNMENT

The federal government is not a party to this contract and is not subject to any obligations or liabilities to the non-federal entity, contractor, or any other party pertaining to any matter resulting from the contract.

1.16 PROGRAM FRAUD AND FALSE OR FRAUDULENT STATEMENTS OR RELATED ACTS

The contractor acknowledges that 31 U.S.C. Chap. 38 (Administrative Remedies for False Claims and Statements) applies to the contractor's actions pertaining to this contract.

1.17 AFFIRMATIVE SOCIOECONOMIC STEPS

If subcontracts are to be let, the prime contractor is required to take all necessary steps identified in 2 C.F.R. § 200.321(b)(1)-(5) to ensure that small and minority businesses, women's business enterprises, and labor surplus area firms are used when possible.

SECTION 00 45 37

STATUS VERIFICATION SYSTEM AFFIDAVIT

PART 1 - GENERAL

1.01 CONTRACTOR

- A. Name: _____
- B. Address: _____

- C. Telephone Number: _____
- D. Facsimile Number: _____

1.02 OWNER

- A. The name of the Owner is Provo City Corporation.

1.03 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202.

PART 2 - REQUIREMENTS

2.01 REGISTRATION AND PARTICIPATION

- A. Bidder has completed a status verification system registration process and is in compliance with the requirements of Utah Code Section 63G-12-302.
- B. Bidder will supply their Company Information page from the status verification system's website (screen shot of enrollment or company information page). The Company Information page shall be submitted in conjunction with this Document 00 45 37 – Status Verification System Affidavit.
- C. Bidder will require similar affidavits of registration and participation, as well as Company Information pages from a status verification system website, for any subcontractor who works under the terms of these Contract Documents.

PART 3 - EXECUTION

3.01 CONTRACTOR'S SUBSCRIPTION AND ACKNOWLEDGEMENT

- A. CONTRACTOR's signature:_____
- B. CONTRACTOR's Status Verification System ID Number:_____
- C. Please print name here:_____
- D. Title:_____
- E. CONTRACTOR's Utah license number:_____

Acknowledgment

State of:_____)
County of:_____) ss

The foregoing instrument was acknowledged before me this _____, 202____
by _____
(person acknowledging and title or representative capacity, if any).

Notary's signature

Residing at

My commission expires:

Notary's seal

END OF SECTION

SECTION 00 45 38

NON-COLLUSION AFFIDAVIT OF PRIME BIDDER

State of: _____)

) ss.

County of: _____)

_____ being first duly sworn deposes and says that:

- (1) He is _____ of _____,
(Owner, partner, officer, representative or agent)
The Bidder that has submitted the attached Bid;
- (2) He is fully informed respecting the preparation and contents of the attached Bid and of all pertinent circumstances respecting such Bid;
- (3) Such Bid is genuine and is not a collusive or sham Bid;
- (4) Neither the said Bidder nor any of its officers, partners, owner, agents, representatives, employees or parties in interest, including this affiant, has in any way colluded, conspired, connived or agreed, directly or indirectly with any other Bidder, firm or person to submit a collusive or sham Bid in connection with such Contract, or has in any manner, directly or indirectly, sought by agreement or collusion or communication or conference with any other Bidder, firm or person to fix the price or prices in the attached Bid or of any other Bidder, or to fix any overhead, profit or cost element of the Bid price of any other Bidder, or to secure through any collusion, conspiracy connivance or unlawful agreement any advantage against the **Provo City Corporation** or any person interested in the proposed Contract; and
- (5) The price or prices quoted in the attached Bid are fair and proper and are not tainted by any collusion, conspiracy, connivance or unlawful agreement on the part of the Bidder or any of its agents, representatives, owners, employees, or parties in interest, including this affiant

Signed _____

(Title)

Subscribed and sworn to before me

This _____ day of _____ 20____

(Title)

My commission expires: _____

END OF SECTION

SECTION 00 52 00

AGREEMENT

PART 1 - GENERAL

1.01 CONTRACTOR

- A. Name: _____
- B. Address: _____

- C. Telephone Number: _____
- D. Facsimile Number: _____

1.02 OWNER

- A. The name of the Owner is Provo City Corporation. The Owner is also referred to as Provo City Water Resources in the Contract Documents.

1.03 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202.

1.04 ENGINEER

- A. Michael M. Chambers, P.E. (Hansen, Allen, & Luce) is the Owner's representative and agent for this Construction Contract who has the rights, authority and duties assigned to the Engineer in the Contract Documents.

1.05 REPRESENTATION REGARDING ETHICAL STANDARDS FOR CITY OFFICERS AND EMPLOYEES AND FORMER CITY OFFICERS AND EMPLOYEES

- A. CONTRACTOR represents that it has not:
 - 1. Provided an illegal gift or payoff to a City officer or employee or former City officer or employee, or his or her relative or business entity.
 - 2. Retained any person to solicit or secure this contract upon an agreement or understanding for a commission, percentage, or brokerage or contingent fee, other than bona fide employees or bona fide commercial selling agencies for the purpose of securing business.

PART 2 - TIME AND MONEY CONSIDERATIONS

2.01 CONTRACT PRICE

- A. The Contract Price includes the cost of the Work specified in the Contract Documents, plus the cost of all bonds, insurance, permits, fees, and all charges, expenses or assessments of whatever kind or character.
- B. The Schedules of Prices awarded from the Bid Schedule (Document 00 43 00) are as follows.
 - 1. Schedule A- Base Bid
- C. An Agreement Supplement is not attached to this Agreement.
- D. Based upon the above awarded schedules and the Agreement Supplement (if any), the Contract Price awarded is: _____ dollars and _____ cents. (\$_____).

2.02 CONTRACT TIME

- A. Substantial Completion of the Work shall occur:
 - 1. by **December 31, 2025**
- B. Any time specified in work sequences in the Summary of Work shall be a part of the Contract Time.
- C. The OWNER anticipates that a Notice to Proceed will be given on the following date, but reserves the right to change such date:
Anticipated date of Notice to Proceed: _____

2.03 PUNCH LIST TIME

- A. The Work will be complete and ready for final payment within 60 days after the date Contractor receives Engineer's Final Inspection Punch List unless exemptions of specific items are granted by Engineer in writing or an exception has been specified in the Contract Documents.
- B. Permitting the Contractor to continue and finish the Work or any part of the Work after the time fixed for its completion, or after the date to which the time for completion may have been extended, whether or not a new completion date is established, shall in no way operate as a waiver on the part of the Owner of any of Owner's rights under this Agreement.

2.04 LIQUIDATED DAMAGES

- A. Time is the essence of the Contract Documents. Contractor agrees that Owner will suffer damage or financial loss if the Work is not completed on time or within any time extensions allowed in accordance with Part 12 of the General Conditions. Contractor and Owner agree that proof of the exact amount of any such damage or loss is difficult to determine. Accordingly, instead of requiring any such proof of damage or specific financial loss for late completion, Contractor agrees to pay the following sums to the Owner as liquidated damages and not as a penalty.
1. **Late Contract Time Completion:** Five hundred dollars and zero cents (\$500.00) for each day or part thereof that expires after the Contract Time until the Work is accepted as Substantially Complete as provided in Article 14.5 of the General Conditions.
 2. **Late Punch List Time Completion:** 50% of the amount specified for Late Contract Time Completion for each day or part thereof if the Work remains incomplete after the Punch List Time. The Punch List shall be considered delivered on the date it is transmitted by email, facsimile, hand delivery or received by the Contractor by certified mail.
 3. **Interruption of Public Services:** No interruption of public services shall be caused by Contractor, its agents or employees, without the Engineer's prior written approval. Owner and Contractor agree that in the event Owner suffers damages from such interruption, the amount of liquidated damages stipulated below shall not be deemed to be a limitation upon Owner's right to recover the full amount of such damages. Five hundred dollars and zero cents (\$500.00) for each day or part thereof of any utility interruption caused by the Contractor without the Engineer's prior written authorization.
- B. **Survey Monuments:** No land survey monument shall be disturbed or moved until Engineer has been properly notified and the Engineer's surveyor has referenced the survey monument for resetting. The parties agree that upon such an unauthorized disturbance it is difficult to determine the damages from such a disturbance, and the parties agree that Contractor will pay as liquidated damages the sum of \$1,000.00 to cover such damage and expense.
- C. **Deduct Damages from Moneys Owed Contractor:** Owner shall be entitled to deduct and retain liquidated damages out of any money which may be due or become due the Contractor. To the extent that the liquidated damages exceed any amounts that would otherwise be due the Contractor, the Contractor shall be liable for such amounts and shall return such excess to the Owner.

PART 3 - EXECUTION

3.01 CONTRACTOR'S SUBSCRIPTION AND ACKNOWLEDGMENT

- A. CONTRACTOR's signature: _____
- B. Please print name here: _____
- C. Title: _____
- D. CONTRACTOR's Utah license number: _____
- E. Notary Acknowledgement: In the Country of _____, State of _____, on the _____ day of _____, 20____, the foregoing instrument was acknowledged before me
(person acknowledging and the title or representative capacity, if any).

Notary's signature _____

Residing at _____

My commission expires: _____

Notary's seal

3.02 OWNER'S SUBSCRIPTION AND ATTESTATION

- A. Reviewed by Project Engineer:

(Project Engineer)
- B. Recommended for approval by City Engineer:

(City Engineer)
- C. OWNER: Provo City Corporation

(Mayor's Signature)
- D. Attest

(SEAL) _____

E. Address for giving notices:

Provo City Corporation
Public Works Department - Water Resources
1377 South 350 East
Provo, Utah 84606

3.03 EFFECTIVE DATE

Owner and Contractor execute this Agreement and declare it in effect as of the ____ day
of _____, _____.

END OF SECTION

SECTION 00 61 13
PERFORMANCE BOND

PART 1 - GENERAL

1.01 BOND

- A. Name: _____
Amount: _____
_____ Dollars (\$_____)

1.02 SURETY

- A. Name: _____
B. Address: _____

C. Telephone Number: _____
D. Facsimile Number: _____

1.03 CONTRACTOR

- A. Name: _____
B. Address: _____

C. Telephone Number: _____
D. Facsimile Number: _____

1.04 OWNER

- A. Provo City Corporation

1.05 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202.

1.06 DEFINED TERMS

- A. Terms used in this Performance Bond which are defined in Article 1.1 of the General Conditions (Document 00 72 00) will have the meanings indicated in the General Conditions.

PART 2 - COVENANTS

2.01 SURETY'S AND CONTRACTOR'S RELATIONSHIP

- A. Surety as surety, and Contractor as principal, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns to the Owner as obligee, for the performance of the Construction Contract, whether awarded or about to be awarded.
- B. If Contractor performs the Construction Contract, the Surety and the Contractor shall have no obligation under this Bond, except to participate in conferences indicated in Article 2.3.

2.02 NOTICE

- A. Notice to the Surety, the Owner or the Contractor shall be sent by certified mail, facsimile, or hand delivered to the address shown on this Bond agreement.
- B. Notices sent as required by paragraph 2.2A shall be effective on the date on which such notice was sent.
- C. Notice may be sent by facsimile. Facsimile notice shall be effective on the date of transmission provided that a confirmation establishing the successful transmission of the notice is sent by first-class mail, postage prepaid, along with a copy of the notice transmitted, no later than twenty-four (24) hours after the facsimile notice is transmitted.
- D. If any notice requires a period of less than seven (7) days for response, the notice shall be sent by facsimile.
- E. If the time for response to any notice expires on a Saturday, Sunday or a legal holiday in the State of Utah, the time shall be extended to the next working day.

2.03 PROCEDURE TO INVOKE SURETY'S OBLIGATION

- A. If the Contractor fails to perform or to comply with the terms of the Construction Contract, and such failure to perform or to comply has not been waived by the Owner, the Owner may notify the Contractor and the Surety, at their addresses described above, that the Owner is considering declaring the Contractor in default.
- B. Before declaring the default, the Owner shall request and attempt to arrange a conference with the Contractor and the Surety to be held at a time and place required by the Owner to discuss methods of performing the Work.

- C. If the Contractor does not attend the conference or agree to cure any deficiencies in the Contractor's performance of the Work to the satisfaction of the Owner, the Owner may declare the Contractor in default and formally terminate the Contractor's right to complete the Work. Such default shall not be declared earlier than 10 days after the Contractor and the Surety have received notice as provided in article 2.2.
- D. If the Contract with the Contractor is terminated, the Owner agrees to pay the unpaid Balance of the Contract Price to the Surety for completion of the Work in accordance with the terms of the Construction Contract or to a contractor selected by the Surety to perform the Work in accordance with the terms of the Construction Contract.

2.04 SURETY'S OPTIONS AT CONTRACTOR TERMINATION

- A. Surety Completes the Work: The Surety may undertake to perform and complete the Work itself, through its agents or through independent contractors.
- B. Surety Obtains Bids or Proposals: The Surety may obtain bids or negotiated proposals from qualified contractors acceptable to the Owner for a contract for performance and completion of the Work.
 - 1. Such bids or proposals shall be prepared by the Surety for execution by the Owner and the completion contractor selected.
 - 2. Surety shall secure the contract with Performance and Payment Bonds executed by a qualified surety equivalent to this Performance Bond and the Payment Bond (Document 00 61 14); and
 - 3. Surety shall pay to the Owner the amount of damages as described in paragraph 2.6 in excess of the balance of the Contract Price incurred by the Owner resulting from the Contractor's default.
 - 4. Surety to Pay Owner: Surety may determine the amount not to exceed the amount of this bond specified in paragraph 1.1B, for which Surety believes it may be liable to pay, and tender payment therefore to the Owner. Owner has sole discretion to accept payment. If the Owner refuses the payment tendered, or the Surety has denied liability in whole or in part, without further notice the Owner shall be entitled to enforce any remedy available to the Owner.

2.05 PROCEDURE FOR OWNER TO DECLARE SURETY IN DEFAULT

- A. The Owner may declare the Surety to be in default upon the following procedures.
 - 1. The Owner shall issue an additional written notice to the Surety, after declaring the Contractor in default as provided in Article 2.3, demanding that the Surety perform its obligations under this Bond.

2. Surety shall respond to the Owner within 15 days after receipt of the Owner's additional notice, either denying the claim or accepting liability and exercising its' options under Article 2.4.

2.06 SURETY'S OBLIGATIONS

- A. After the Owner has terminated the Contractor's right to complete the Construction Contract, and if the Surety elects to complete the Construction Contract as provided in Article 2.4, then the responsibilities of the Surety to the Owner shall not be greater than those of the Contractor under the Construction Contract, and the responsibilities of the Owner to the Surety shall not be greater than those of the Owner under the Construction Contract.
- B. To the limit of the amount of this Bond, but subject to commitment by the Owner to pay all valid and proper payments made to or on behalf of the Contractor under the Construction Contract, the Surety is obligated, without duplication, for:
 1. the responsibilities of the Contractor for correction of Defective Work and completion of the Construction Contract;
 2. design professional and delay costs resulting from the Contractor's default, and resulting from the actions or failure to act of the Surety under article 2.4; and
 3. liquidated damages which are or may become due for any reason.

2.07 UNRELATED OBLIGATIONS OF THE CONTRACTOR

- A. The Surety and the Owner shall not be liable to others for obligations of the Contractor that are unrelated to the Construction Contract, and the Balance of the Contract Price shall not be reduced or changed on account of any such unrelated obligations.
- B. No right of action shall accrue on this Bond to any person or entity other than the Owner or its heirs, executors, administrators, or successors.

2.08 SURETY WAIVES NOTICE OF ANY CHANGE

- A. Surety hereby waives notice of any change, including changes of Contract Time, Contract Price and scope of Work, to the Construction Contract or to related subcontracts, purchase orders and other obligations.

2.09 VENUE

- A. Any suit or action commenced by Owner under this Bond shall be for action in a court of competent jurisdiction in the State of Utah.

PART 3 - EXECUTION

3.01 EFFECTIVE DATE

- A. Surety and Contractor execute this Bond agreement and declare it to be in effect as of the _____ day of _____, _____.

3.02 CONTRACTOR'S SUBSCRIPTION AND ACKNOWLEDGMENT

- A. Type of organization: _____
(corporation, partnership, individual, etc.)
- B. If Contractor is a corporation, attach a corporate resolution evidencing Contractor's authority to sign.
- C. Contractor's signature: _____
- D. Please print name here: _____
- E. Title: _____
- F. Notary Acknowledgement: In the Country of _____, State of _____, on the _____ day of _____, 20____, the foregoing instrument was acknowledged before me

(person acknowledging and the title or representative capacity, if any).

Notary's signature

Residing at

My commission expires:

Notary's seal

3.03 SURETY'S SUBSCRIPTION AND ACKNOWLEDGMENT

- A. Attach evidence of Surety's corporate authority to sign.
- B. Surety's signature: _____
- C. Please print name here: _____
- D. Title: _____
- E. **Acknowledgment:** In the County of _____, State of _____, on the _____ day of _____, _____, before me, the undersigned notary, personally appeared _____, who proved to me his/her identity through documentary evidence in the form of a _____ to be the person whose name is signed as the authorized Surety and acknowledged to me that this document was signed voluntarily for its stated purpose.

Notary Public signature

Notary Public seal

END OF SECTION

SECTION 00 61 14

PAYMENT BOND

PART 1 - GENERAL

1.01 BOND

- A. Name: _____
- B. Amount: _____
_____ Dollars (\$_____)

1.02 SURETY

- A. Name: _____
- B. Address: _____

- C. Telephone Number: _____
- D. Facsimile Number: _____

1.03 CONTRACTOR

- A. Name: _____
- B. Address: _____

- C. Telephone Number: _____
- D. Facsimile Number: _____

1.04 OWNER

- A. Provo City Corporation

1.05 CONSTRUCTION CONTRACT

- A. The Construction Contract is known as Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202

1.06 DEFINED TERMS

- A. Terms used in this Performance Bond which are defined in Article 1.1 of the General Conditions (Document 00 72 00) will have the meanings indicated in the General Conditions.

PART 2 - COVENANTS

2.01 SURETY'S AND CONTRACTOR'S RELATIONSHIP

- A. Surety as surety, and Contractor as principal, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns to the Owner as obligee, for the performance of the Construction Contract, whether awarded or about to be awarded.
- B. If Contractor performs the Construction Contract, the Surety and the Contractor shall have no obligation under this Bond.

2.02 NOTICE

- A. Notice to the Surety, the Owner or the Contractor shall be sent by certified mail, facsimile, or hand delivered to the address shown on this Bond agreement.
- B. Notices sent as required by paragraph 2.2A shall be effective on the date on which such notice was sent.
- C. Notice may be sent by facsimile. Facsimile notice shall be effective on the date of transmission provided that a confirmation establishing the successful transmission of the notice is sent by first-class mail, postage prepaid, along with a copy of the notice transmitted, no later than twenty-four (24) hours after the facsimile notice is transmitted.
- D. If any notice requires a period of less than seven (7) days for response, the notice shall be sent by facsimile.
- E. If the time for response to any notice expires on a Saturday, Sunday or a legal holiday in the State of Utah, the time shall be extended to the next working day.

2.03 CONDITIONS OF SURETY'S LIABILITY

- A. With respect to the Owner, this Bond agreement shall be null and void if the Contractor promptly takes the following actions:
 - 1. promptly makes payment, directly or indirectly, for all sums due Claimants, and
 - 2. defends, indemnifies and saves harmless the OWNER from all claims, demands, Liens or suits by any person or entity who furnished labor, materials or equipment for use in the performance of the Work, provided the OWNER has tendered defense of such claims, demands, liens or suits to the CONTRACTOR and the Surety.

2.04 PROCEDURE TO INVOKE SURETY'S OBLIGATION

- A. **Concerning Claimants who have a Direct Contract with the Contractor:** The Surety shall have no obligation to Claimants under this Bond who are employed by or have a direct contract with the Contractor until Claimants have given notice to the Surety at the address shown on this Bond agreement and sent a copy, or notice thereof, to the Owner, stating that a claim is being made under this Bond and, with substantial accuracy, the amount of the claim.
- B. **Concerning Claimant who does not have a Direct Contract with the Contractor:** The Surety shall have no obligation to Claimant under this Bond who does not have a direct contract with the Contractor until Claimant takes the following actions.
 - 1. The Claimant shall furnish written notice to the Contractor and send a copy, or notice thereof, to the Owner, within 90 days after having last performed labor or last furnished materials or equipment included in the claim stating, with substantial accuracy, the amount of the claim and the name of the party to whom the materials were furnished or supplied or for whom the labor was done or performed.
 - 2. The Claimant shall have either received a rejection in whole or in part from the Contractor, or not received within 15 days of furnishing the above notice any communication from the Contractor by which the Contractor has indicated the claim will be paid directly or indirectly.
 - 3. Not having been paid within the above 15 days, the Claimant shall have sent a written notice to the Surety at the address described on this Bond agreement and sent a copy, or notice thereof, to the Owner stating that a claim is being made under this Bond and enclosing a copy of the previous written notice furnished to the Contractor.

2.05 SURETY'S OPTION TO SETTLE CLAIMS

- A. When the Claimant has satisfied the conditions of article 2.4, the Surety shall promptly and at the Surety's expense take the following actions.
 - 1. Send an answer to the Claimant, with a copy to the Owner, within 45 days after receipt of the claim, stating the amounts that are undisputed and the basis for challenging any amounts that are disputed; and
 - 2. Pay or arrange for payment of any undisputed amounts.

2.06 SURETY'S OBLIGATION

- A. Surety's total obligations under this bond shall not exceed the amount of this Bond, and the amount of this Bond shall be credited for any payments made in good faith by the Surety.

2.07 USE OF FUNDS

- A. Amounts owed by Owner to Contractor under the Construction Contract shall be used for the performance of the Construction Contract and to satisfy claims, if any, against the Performance Bond (Document 00 61 13). By the Contractor furnishing and the Owner accepting this Bond, they agree that all funds earned by the Contractor in the performance of the Work are dedicated as follows:
 - 1. The Owner has first priority to use the funds for the completion of the Work.
 - 2. The Contractor and the Surety have second priority to use the funds to satisfy the obligations of the Contractor and the Surety under this Bond.

2.08 UNRELATED OBLIGATIONS OF THE CONTRACTOR

- A. The Surety and the Owner shall not be liable to Claimants or others for obligations of the Contractor that are unrelated to the Construction Contract.
- B. The Owner shall not be liable for payment of any damages, costs or expenses of any Claimant under this Bond, and shall have under this Bond no obligations to make payments to, give notices on behalf of, or otherwise have obligations to Claimants under this Bond.

2.09 SURETY WAIVES NOTICE OF ANY CHANGE

- A. Surety hereby waives notice of any change to the Construction Contract including changes of Contract Time, Contract Price, and scope of Work, or to related subcontracts, purchase orders or other obligations.

2.10 VENUE

- A. Any suit or action commenced by a Claimant under this Bond shall be for action in a court of competent jurisdiction in the State of Utah.

2.11 COPIES OF THIS BOND

- A. Upon request by any person or entity appearing to be a potential beneficiary of this Bond, the Contractor or Owner shall promptly furnish a copy of this Bond or shall permit a copy to be made.

PART 3 - EXECUTION

3.01 EFFECTIVE DATE

- A. Surety and Contractor execute this Bond agreement and declare it to be in effect as of the _____ day of _____, _____.

3.02 CONTRACTOR'S SUBSCRIPTION AND ACKNOWLEDGMENT

- A. Type of organization: _____
(corporation, partnership, individual, etc.)
- B. If Contractor is a corporation, attach a corporate resolution evidencing Contractor's authority to sign.
- C. CONTRACTOR's signature: _____
- D. Please print name here: _____
- E. Title: _____
- F. Notary Acknowledgement: In the Country of _____, State of _____, on the _____ day of _____, 20____, the foregoing instrument was acknowledged before me

(person acknowledging and the title or representative capacity, if any).

Notary's signature

Residing at

My commission expires:

Notary's seal

3.03 SURETY'S SUBSCRIPTION AND ACKNOWLEDGMENT

- A. Attach evidence of Surety's corporate authority to sign.
- B. Surety's signature: _____
- C. Please print name here: _____
- D. Title: _____
- E. **Acknowledgment:** In the County of _____, State of _____, on the _____ day of _____, _____, before me, the undersigned notary, personally appeared _____, who proved to me his/her identity through documentary evidence in the form of a _____ to be the person whose name is signed as the authorized Surety and acknowledged to me that this document was signed voluntarily for its stated purpose.

Notary's signature _____

Residing at _____

My commission expires:

Notary's seal

END OF SECTION

SECTION 00 62 16

CERTIFICATE OF INSURANCE

PART 1 - GENERAL

1.01 PROCEDURE

- A. For filing purposes, add Certificates of Insurance to the Contract Documents following this page.
- B. Certificates of Insurance must include all requirements in Section 5.2 of the Modifications to General Conditions (Supplementary Conditions) (Document 00 73 00).

END OF SECTION

SECTION 00 73 00

MODIFICATIONS TO GENERAL CONDITIONS
(Supplementary Conditions)

This document changes provisions specified in the General Conditions in the Manual of Standard Specifications published by the Utah Chapter of the American Public Works Association.

Add the following paragraphs to Article 2.2 (page 20).

PART 1 -

PART 2 -

2.01

2.02 COPIES OF DOCUMENTS

- A. Owner shall not furnish to Contractor published Contract Documents which include the Manual of Standard Plans and the Manual of Standard Specifications. Such documents shall be purchased separately by the Contractor.
- B. Copies of all Contract Documents including the Manual of Standard Plans and the Manual of Standard Specifications shall be provided on site by the Contractor.

Modify paragraph 2.5C of the General Conditions (page 21) to read as follows:

2.03

2.04

2.05 BEFORE STARTING CONSTRUCTION

- A. Field Office: Contractor shall provide and maintain an on-site field office. Field office shall include internet service with wireless capabilities in the field during performance of the Work such that the Engineer and Owner may always contact Contractor for transmittal of plans, instructions and dissemination of project information.

Modify Article 5.1 (page 28) to read as follows:

PART 3 -

PART 4 -

PART 5 -

5.01 PERFORMANCE, PAYMENT AND OTHER BONDS

- A. Prior to OWNER executing the Agreement, Contractor shall file with the Owner a good and sufficient performance Bond and a payment Bond, each in the sum of not less than 100 percent of the Contract Price.
- B. The Bonds shall be executed by the Contractor and secured by a company duly and regularly authorized to do a general surety business in the State of Utah and either (i) named in the current U.S. Treasury Department's listing of approved sureties (Department Circular 570) (as amended) with an underwriting limitation equal to or greater than the Contract Price which the Bond guarantees, or (ii) with a current "A-" rating or better in A.M. Best Co., Inc's. Best Insurance Reports, Property and Casualty Edition.
- C. The Performance Bond shall guarantee the faithful performance of the Construction Contract by the Contractor and the payment Bond shall guarantee the payment of labor and materials. The Bonds shall inure by their terms to the benefit of the OWNER. Neither this nor any other provision requiring a performance Bond shall be construed to create any rights in any third party Claimant as against the OWNER for performance of the Work under the Construction Contract.
- D. All Bonds required by the Contract Documents to be purchased and maintained by Contractor shall be obtained from surety companies that are duly licensed or authorized in the jurisdiction in which the Project is located to issue Bonds for the limits so required. Such surety companies shall also meet such additional requirements and qualifications as may be provided in the Supplementary General Conditions.
- E. If the surety on any Bond furnished by Contractor is subject to any proceeding under the Bankruptcy Code (Title 11, United States Code) or becomes insolvent or its right to do business is terminated in the State of Utah or it ceases to meet the requirements of this Article, Contractor shall, within 15 days thereafter, substitute another Bond and surety, both of which must be acceptable to Owner.

Modify Article 5.2 (page 28) to read as follows:

5.02 INSURANCE

- A. Contractor shall procure and maintain for the duration of the contract, insurance against claims for injuries to persons or damage to property which may arise from or in connection with the performance of the work hereunder by the contracting party, his agents,

representatives, employees or subcontractors. The cost of such insurance shall be included in the Contracting party's proposal.

REQUIRED INSURANCE POLICIES

Contractor (the Contractor) shall maintain or cause to be maintained on its behalf insurance policies of the types required below with insurance companies authorized to do business in the State of Utah, (i) having a Best Insurance Reports rating of "A" or better and a financial size category of "X" or higher, or (ii) otherwise being acceptable to the City with coverage limits and provisions at least sufficient to satisfy the requirements set forth below.

Workers' Compensation Insurance: Statutory workers' compensation insurance (Part A). Such insurance shall also include employer's liability (Part B) insurance in a limit of not less than \$1,000,000 for each: accident, disease, employee. No owner or officer may be excluded.

General Liability Insurance: Commercial general liability insurance on an occurrence basis arising out of claims for bodily injury (including death) and property damage. Such insurance shall provide coverage for ongoing operations and products-completed operations, blanket contractual, broad form property damage, personal and advertising injury, independent contractors and sudden and accidental pollution liability with not less than \$2,000,000 per occurrence limit combined bodily injury and property damage, with not less than \$2,000,000 aggregate limit, provided the general policy aggregate shall apply separately to the Contractor on a per project basis. Any aggregate limit that does not apply separately to the premises shall be at least double the required per occurrence limit.

Automobile Liability Insurance: Automobile liability insurance for the Contractor's liability arising out of the use of owned (if any), leased (if any), non-owned and hired vehicles of the Contractor, with no less than \$2,000,000 limit per accident for combined bodily injury and property damage and containing appropriate no-fault insurance provisions wherever applicable. All owned and/or leased automobiles shall be covered using symbol "1" (any auto).

Professional Liability (errors & omissions) Insurance: coverage for a limit of \$2,000,000. Insurance shall be carried for two years after the work has been completed.

- B. Additional Insured Endorsements: All policies of liability insurance required to be maintained by the Contractor shall be endorsed to name the City and the Engineer, Hansen, Allen & Luce, Inc. and AECOM Technical Services, Inc., as additional insured for ongoing operations (ISO CG 20 10 or equivalent) and completed operations (ISO CG 20 37 or equivalent) (except for insurance policies required in Section 1 and 3 above).
- C. Primary and Non-Contributory Endorsements: The Contractor's insurance coverage shall be a primary insurance as respects to the City, its officers, officials, employees, volunteers, and the Engineer. Any insurance or self-insurance maintained by the City, its officers, officials, employees, volunteers or Engineer shall be in excess of the contracting party's insurance and shall not contribute with it.

- D. Waiver of Subrogation Endorsements: The Contractor hereby waives any and every claim for recovery from the City, Lenders and their respective offices and employees for any and all loss or damage covered by any of the insurance policies to be maintained under this Contractor agreement to the extent that such loss or damage is recovered under any such policy. To the extent the foregoing waiver would preclude coverage under any insurance required by this Section, the Contractor shall give written notice of the terms of such waiver to each insurance company which has issued, or which may issue in the future, any such policy of insurance (if such notice is required by the insurance policy) and shall cause each such insurance policy to be properly endorsed, or to otherwise contain one or more provisions that prevent the invalidation of the insurance coverage by reason of such a waiver.
- E. Severability of Interests: The contracting party's insurance shall apply separately to each insured against whom claim is made or suit is brought, except with respects to the limits of the insurer's liability.
- F. Deductibles and Self-Insured Retentions: Any deductibles or self-insured retention, exceeding 5% limit of policy, must be declared to and approved by the City. At the option of the City, either; the insurer may be required to reduce or eliminate such deductibles or self-insured retention as respects the City, its officers, officials and employees; or the contracting party may be required to procure a bond guaranteeing payment of losses and related investigations, claim distribution and defense expenses.
- G. Notice of Incident or Accident: Contracting party shall agree to disclose to the City, all incidents or occurrences of accident, injury, and/or property damage, regardless of whether such incidents are submitted as claims under the contractor's insurance policies.
- H. Evidence and Verification of Insurance: On or before the effective date of each policy and on an annual basis at least 10 days prior to each policy anniversary, the Contractor shall furnish the City with (1) certificates of insurance or binders, in a form acceptable to the City, evidencing all of the insurance required by the provisions of this Section. Contractor shall provide a certificate of insurance verifying completed operations coverage for a period of not less than two years after project completion. Certificates and endorsements are to be signed by a person authorized by that insurer to bind coverage on its behalf. The certificates and endorsements are to be furnished to and accepted by the City before work commences. The City reserves the right to require complete, certified copies of all required insurance policies, with all endorsements, at any time.
- I. Claims-Made Policies: If any policy is a claims-made policy, the policy shall provide the Contractor the right to purchase, upon cancellation or termination by refusal to renew the policy, an extended reporting period (Tail) of not less than two years. The Contractor agrees to purchase such an extended reporting period if needed to ensure continuity of coverage. The Contractor's failure to purchase such an extended reporting period as required by this paragraph shall not relieve it of any liability under this Contract. If the policy is a claims-made policy, the retroactive date of any such policy shall be not later than the date this Contract is executed by the parties hereto. If the Contractor purchases a subsequent claims-made policy in place of any prior claims-made policy, the retroactive

date of such subsequent policy shall be no later than the date this Contract is executed by the parties hereto.

- J. Policy Cancellation and Change: All insurance policies shall be endorsed so that if at any time they are canceled, such cancellation shall not be effective for the City for 30 days, except for non-payment of premium which shall be for 10 days. If any material change in coverage should occur, the Contractor shall provide notice of any material change in coverage to the City immediately.
- K. Liability Limits: The liability limits shown in this Section are minimum requirements. To the extent the Contractor maintains, or causes to be maintained on its behalf, liability limits which are higher than the minimum limits stated in this Section, the higher liability limits shall be required of the Contractor.
- L. Failure to Maintain Insurance: In the event the Contractor fails, or fails to cause others on their behalf, to take out or maintain the full insurance coverage required by this Section, the City, upon 30 days' prior notice (unless the required insurance would lapse within such period, in which event notice will be given as soon as reasonably possible) to the Contractor of any such failure, may (but shall not be obligated to) take out the required policies of insurance and pay the premiums on the same. All amounts so advanced thereof by the City shall become an additional obligation of the Contractor to the City, and the Contractor shall pay such amounts to the City, together with interest thereon from the date so advanced. Any failure to comply with reporting provisions of the policies shall not affect coverage provided to the City, its officers, officials, employees or volunteers.
- M. No Duty to Verify or Review: No provision of this Section or any provision of any Document related to this agreement shall impose on the City any duty or obligation to verify the existence or adequacy of the insurance coverage maintained by the Contractor, nor shall City be responsible for any representations or warranties made by or on behalf of the Contractor to any insurance company or underwriter. Any failure on the part of the City to pursue or obtain the evidence of insurance required by this agreement from the Contractor and/or failure of the City to point out any non-compliance of such evidence of insurance shall not constitute a waiver of any of the insurance requirements in this agreement.
- N. Subcontractors: Contractor shall include all subcontractors as an insured under its policies or shall furnish separate certificates and endorsements for each subcontractor. All coverages for subcontractors shall be subject to the requirements stated herein.
- O. Indemnification/Liability: Contractor shall indemnify and hold harmless the City, its officers, agents, employees and volunteers from all damages, costs or expenses in law or equity, including attorney's fees, that may at any time arise or be set up because of damages to property, bodily injury or personal injury received by reason of or in the course of providing services to the City but only to the extent caused by any willful, negligent or wrongful act or omission of the contracting party, any of their employees or any subcontractors.

- P. Loss Control and Safety: The Contractor shall retain control over its employees, agents, servants, and subcontractors, as well as control over its invitees, and its activities on and about the subject premises and the manner in which such activities shall be undertaken and to that end, the Contractor shall not be deemed to be an agent of the City. Precaution shall be exercised at all times by the Contractor for the protection of all persons, including employees and property. The Contractor shall make special effort to detect hazards and shall take prompt action where loss control/safety measures should reasonably be expected.
- Q. The Contractor shall not commence Work under this Agreement until all of the insurance required herein shall have been obtained by the Contractor. The Contractor shall furnish to the Owner Certificates of Insurance verifying that such insurance has been obtained. Such certificates will provide that Owner will receive at least thirty (30) days prior written notice of any material change in, cancellation of, or non-renewal of such insurance.

Add the following paragraphs to Article 6.8 (page 35).

PART 6 -

6.01

6.02

6.03

6.04

6.05

6.06

6.07

6.08 LAWS AND REGULATIONS

- A. All Bidders are required to follow the requirements of Utah Code Annotated 63G-12-302 which prohibits the Owner from entering into any contract for the performance of services with any successful bidder who does not first provide the Owner with proof of registration and participation in a federally approved immigration status verification system to ensure that their employees are legally authorized to work in the United States. Failure to provide the required proof may be grounds for rejection of an otherwise successful bid. By submitting a bid in response to this RFB, Contractor certifies that it does not, and will not during the performance of this contract, knowingly employ, or subcontract with any entity which employs workers who are not legally authorized to work in the United States. Contractor agrees to require all its employees to provide proof of their eligibility to work in the United States and agrees to use all reasonable means to verify that proof. Contractor

further agrees to require any subcontractors engaged to work on the project to sign a Certification of Legal Work Status and submit the Certification to the Owner prior to any work being performed by the subcontractors. Contractor agrees to provide to the Owner all documents necessary to verify compliance with applicable State and Federal immigration and labor laws. If Contractor knowingly employs workers or subcontractors in violation of 8 USC § 1324a, such violation shall be cause for unilateral cancellation of the contract between Contractor and Owner. In addition, Contractor may be suspended from participating in future projects with the Owner. In the event this contract is terminated due to a violation of 8 USC § 1324a by Contractor or a subcontractor of Contractor, Contractor shall be liable for any and all costs associated with such termination, including, but not limited to, any damages incurred by the Owner as well as attorney fees. For purposes of compliance, the Owner requires Contractor and subcontractors to use an immigration status verification system such as E-Verify, or other approved system as outlined in Utah Code Annotated 63G-12-302, to verify the employment eligibility of all employees. Contractor and subcontractors must maintain up to date documentation of the status verification system inquiry regarding each employee and must provide this information to the Owner prior to beginning the project.

Add the following paragraphs to Article 9.3 (page 47).

9.3 AUTHORITY AND DUTIES OF RESIDENT PROJECT REPRESENTATIVE

- D. The Resident Project Representative (RPR) will be Engineer's representative at the Site, will act as directed by and under the supervision of Engineer, and will confer with Engineer regarding RPR's actions.
 - 1. General: RPR's dealings in matters pertaining to the Work in general shall be with Engineer and Contractor. RPR's dealings with Subcontractors shall only be through or with the full knowledge and approval of Contractor. RPR shall generally communicate with Owner only with the knowledge of and under the direction of Engineer.
 - 2. Schedules: Review the progress schedule, schedule of Shop Drawing and Sample submittals, and Schedule of Values prepared by Contractor and consult with Engineer concerning acceptability.
 - 3. Conferences and Meetings: Attend meetings with Contractor, such as preconstruction conferences, progress meetings, job conferences, and other Project-related meetings.
 - 4. Liaison:
 - a. Serve as Engineer's liaison with Contractor. Working principally through Contractor's authorized representative or designee, assist in providing information regarding the provisions and intent of the Contract Documents.
 - b. Assist Engineer in serving as Owner's liaison with Contractor when Contractor's operations affect Owner's on-Site operations.

- c. Assist in obtaining from Owner additional details or information, when required for proper execution of the Work.
- 5. Interpretation of Contract Documents: Report to Engineer when clarifications and interpretations of the Contract Documents are needed and transmit to Contractor clarifications and interpretations as issued by Engineer.
- 6. Shop Drawings and Samples:
 - a. Record date of receipt of Samples and Contractor-approved Shop Drawings.
 - b. Receive Samples which are furnished at the Site by Contractor and notify Engineer of availability of Samples for examination.
 - c. Advise Engineer and Contractor of the commencement of any portion of the Work requiring a Shop Drawing or Sample submittal for which RPR believes that the submittal has not been approved by Engineer.
- 7. Modifications: Consider and evaluate Contractor's suggestions for modifications in Drawings or Specifications and report such suggestions, together with RPR's recommendations, if any, to Engineer.
- 8. Review of Work and Rejection of Defective Work:
 - a. Conduct on-Site observations of Contractor's work in progress to assist Engineer in determining if the Work is in general proceeding in accordance with the Contract Documents.
 - b. Report to Engineer whenever RPR believes that any part of Contractor's work in progress is defective, will not produce a completed Project that conforms generally to the Contract Documents, or will imperil the integrity of the design concept of the completed Project as a functioning whole as indicated in the Contract Documents, or has been damaged, or does not meet the requirements of any inspection, test or approval required to be made; and advise Engineer of that part of work in progress that RPR believes should be corrected or rejected or should be uncovered for observation, or requires special testing, inspection or approval.
- 9. Inspections, Tests, and System Start-ups:
 - a. Verify that tests, equipment, and systems start-ups and operating and maintenance training are conducted in the presence of appropriate Owner's personnel, and that Contractor maintains adequate records thereof.
 - b. Observe, record, and report to Engineer appropriate details relative to the test procedures and systems start-ups.
- 10. Records:

- a. Prepare a daily report, recording Contractor's hours on the Site, Subcontractors present at the Site, weather conditions, data relative to questions of Change Orders, Field Orders, Work Change Directives, or changed conditions, Site visitors, deliveries of equipment or materials, daily activities, decisions, observations in general, and specific observations in more detail as in the case of observing test procedures; and send copies to Engineer.
 - b. Maintain records for use in preparing Project documentation.
- 11. Reports:
 - a. Furnish to Engineer periodic reports as required of progress of the Work and of Contractor's compliance with the Progress Schedule and schedule of Shop Drawing and Sample submittals.
 - b. Draft and recommend to Engineer proposed Change Orders, Work Change Directives, and Field Orders. Obtain backup material from Contractor.
 - c. Immediately notify Engineer of the occurrence of any Site accidents, emergencies, acts of God endangering the Work, force majeure or delay events, damage to property by fire or other causes, or the discovery of any Constituent of Concern or Hazardous Environmental Condition.
- 12. Payment Requests: Review applications for payment with Contractor for compliance with the established procedure for their submission and forward with recommendations to Engineer, noting particularly the relationship of the payment requested to the Schedule of Values, Work completed, and materials and equipment delivered at the Site but not incorporated in the Work.
- 13. Certificates, Operation and Maintenance Manuals: During the course of the Work, verify that materials and equipment certificates, operation and maintenance manuals and other data required by the Contract Documents to be assembled and furnished by Contractor are applicable to the items actually installed and in accordance with the Contract Documents, and have these documents delivered to Engineer for review and forwarding to Owner prior to payment for that part of the Work.
- 14. Completion:
 - a. Participate in Engineer's visits to the Site to determine Substantial Completion, assist in the determination of Substantial Completion and the preparation of a punch list of items to be completed or corrected.
 - b. Participate in Engineer's final visit to the Site to determine completion of the Work, in the company of Owner and Contractor, and prepare a final punch list of items to be completed and deficiencies to be remedied.

- c. Observe whether all items on the final list have been completed or corrected and make recommendations to Engineer concerning acceptance and issuance of the notice of acceptability of the work.

E. The RPR shall not:

1. Authorize any deviation from the Contract Documents or substitution of materials or equipment (including “or-equal” items).
2. Exceed limitations of Engineer’s authority as set forth in the Contract Documents.
3. Undertake any of the responsibilities of Contractor, Subcontractors, or Suppliers.
4. Advise on, issue directions relative to, or assume control over any aspect of the means, methods, techniques, sequences, or procedures of Contractor’s work.
5. Advise on, issue directions regarding, or assume control over security or safety practices, precautions, and programs in connection with the activities or operations of Owner or Contractor.
6. Participate in specialized field or laboratory tests or inspections conducted off-site by others except as specifically authorized by Engineer.
7. Accept Shop Drawing or Sample submittals from anyone other than Contractor.
8. Authorize Owner to occupy the Project in whole or in part.

Replace Article 14.2 Paragraph E with the following:

Retainage: Payments will be made for work and labor performed and materials furnished under the contract according to the schedule of rates and prices and the specifications attached and made a part thereof. Partial payments under the contract will be made at the request of the Contractor once each month upon partial estimates by the Engineer, as hereinafter specified. There will be reserved and retained from monies earned by the Contractor, as determined by such monthly estimates, a sum equal to five (5) percent of all amounts of such estimates.

Cost of materials, properly stored, protected and insured at the site of the work will be paid on monthly estimates only when so provided for in the special provisions, and then only for the specific materials listed therein for partial payment. In preparing the monthly estimates, advancement will be made therein for ninety percent (90%) of the cost of such materials, as evidenced by invoices to the Contractor. Advancement will not be made for any item of material amounting to less than five hundred dollars (\$500.00). All materials must conform to the requirements of the specifications; however, advancement for materials will not constitute acceptance, and any faulty material will be condemned although advancement may have been made for same in the estimates. Deductions at the same rates, and equal in amount to the advancements, will be made on the estimates as the material is used.

Quantities used for progress estimates shall be considered only as approximate and provisional, and shall be subject to recalculation, adjustment and correction by the Engineer in subsequent progress estimates and in final estimates. Inclusion of any quantities in progress estimates, or failure to disapprove the work at the time of progress estimate, shall not be construed as acceptance of the corresponding work or materials.

In the event that an unforeseen condition beyond the control of the Contractor will materially delay the final completion of a contract and if the retention of the monies reserved will work undue hardship upon the Contractor, he may request payment of the retained percentage. If no claims have thus far been filed against the contract and if no taxes have been certified as due or about to become due by the State Tax Commission, the Owner, at its discretion, may pay the retained percentage or so much of it as appears to be proper, but no payment shall be made until the Contractor will have delivered to the Owner an acceptable bond in the full amount of the retained percentage thereupon released.

Payment of the retained percentage shall be withheld for a period of thirty (30) days following the final acceptance by the Owner, and shall be paid the Contractor at the expiration of said thirty (30) days in event no claims, as provided by law, have been filed against such funds; and provided further, that releases have been obtained from the Utah Labor Commission and also, except for contract totaling less than \$20,000.00, the Utah State Tax Commission, the State of Utah Employment Security Department, and all other departments and agencies having jurisdiction over the activities of the Contractor. In the event such claims are filed, the Contractor shall be paid such retained percentages less an amount sufficient to pay any such claims, together with a sum sufficient to pay the cost of such action, and to cover attorney fees as determined by the Owner.

END OF SECTION

SECTION 00 91 13

ADDENDA

PART 1 - GENERAL

1.01 PROCEDURE

- A. For filing purposes, add Addenda and Modifications to the Contract Documents following this page.

END OF SECTION

SECTION 00 92 45

CHANGE ORDER FORM

CHANGE ORDER No. _____

Project: Provo River Water Treatment Plant Project, Bid No. PROVOEN202323202

Date of Issuance:

Owner: Provo City Corporation

Contractor:

Owner's Rep:

Contact For: Shane Jones, P.E. - Principal Engineer, Provo City Water Resources

You are directed to make the following changes in the Contract Documents:

Description:

Purpose of Change Order:

Attachments:

Change in Contract Price:

Original Contract Price: \$

Prior Change Orders No. to No. _____

Contract Price with all approved Change Orders: \$ _____

Change to CONTRACT TIME:

The CONTRACT TIME will be increased by calendar days.

The date for completion of all work will be _____.
(Date)

Approvals Required:

To be effective, this order must be approved by the Federal Agency if it changes the scope or objective of the PROJECT, or as may otherwise be required by the SUPPLEMENTAL GENERAL CONDITIONS.

RECOMMENDED:

by _____
Project Manager

APPROVED:

by _____
Owner

ACCEPTED:

by _____
Contractor

END OF SECTION

SECTION 01 11 00
SUMMARY OF WORK

PART 1 - GENERAL

1.01 SUMMARY:

A. Section Includes:

1. Project information.
2. Work covered by Contract Documents.
3. Access to site.
4. Work restrictions.
5. Specification and drawing conventions.

B. Related Requirements:

1. Division 01 Section "Temporary Facilities" for limitations and procedures governing temporary use of Owner's facilities.

1.02 PROJECT INFORMATION:

- A. Owner's Representative: Shane Jones, PE, Project Manager, sjones@provo.org, 801-852-6773.
- B. Engineer: Michael M. Chambers, PE, PMP, Engineer mchambers@halengineers.com, 801-803-1828 and John Krinks, PE, Engineer, john.krinks@aecom.com, 614-493-3359.
- C. Engineer's Consultants: The Engineer has retained the following design professionals who have prepared designated portions of the Contract Documents:
1. Pump Station Electrical: Bob Hillyer, PE, bhillyer@heatheng.com, 385-202-7425.
 2. Pump Station HVAC: Karson Halverson, PE, khalverson@heatheng.com, 801-322-0487
 3. Pump Station Structural: Robert Conder, SE, robert@conderengineering.com, 801-597-4860
- D. Project Website: A project Website administered by Engineer will be used for purposes of managing communication and documents during the construction stage.

1. See Division 01 Section "Internet Based Construction Management System" for requirements for the Project website.

1.03 WORK COVERED BY CONTRACT DOCUMENTS:

- A. The Work of Project is defined by the Contract Documents and consists of the following:
 1. Construction includes, but is not limited to, the following: Work consists of the construction of a 30 MGD ultrafiltration membrane drinking water treatment plant including, but not limited to, the main Water Treatment Plant Facility with Administration Building, 2 MG Clearwell with drain vault and overflow structure, High Service Pump Station, 36-inch diameter Transmission Pipeline with valve vault, 42-inch diameter Mill Race Pipeline with diversion box, electrical and controls including three (3) 1,000 kW natural gas generators, security cameras, fencing, and site restoration, paving, and landscaping.
 2. Project will be constructed under a single prime contract.

1.04 ACCESS TO SITE:

- A. Use of Site: Limit use of Project site to areas within the Contract limits indicated. Only temporary closures will be allowed on portions of Project site beyond areas in which the Work is indicated.
 1. Shared Raintree Apartments Driveway, Walkways and Entrances: Keep driveways, parking lots, and entrances serving the Raintree Apartments and as noted on the Contract Drawings clear and available to residents, Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
 - a. Limited closures will be permitted and must be coordinated with the Raintree Apartments property manager.
- B. BYU Easements: Work within BYU property shall only be conducted between February 1 to August 30 of 2023 or 2024. The work may be deferred to the 2024 season but work shall be completed in one construction season.
- C. UDOT Right-of-Way: Work within University Avenue shall not begin until after April 1 and shall be complete by September 29.

1.05 WORK RESTRICTIONS:

- A. Work Restrictions, General: Comply with restrictions on construction operations.
 1. Comply with limitations on use of public streets and with other requirements of authorities having jurisdiction.

- B. On-Site Work Hours: Limit work to normal business working hours of 7:00 a.m. to 6:00 p.m., Monday through Friday, excluding legal holidays, unless otherwise approved by Owner.
 - 1. Weekend Hours and Early Morning Hours are not allowed unless approval is provided by Owner.
 - C. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after providing temporary utility services according to requirements indicated:
 - 1. Notify Owner not less than two days in advance of proposed utility interruptions.
 - 2. Obtain written permission before proceeding with utility interruptions.
 - D. Noise, Vibration, and Odors: Coordinate operations that may result in high levels of noise and vibration, odors, or other disruption to adjacent residents with Owner.
 - 1. Notify Owner not less than two days in advance of proposed disruptive operations.
 - 2. Obtain Owner's written permission before proceeding with disruptive operations.
 - E. Nonsmoking Building: Smoking is not permitted within the building or within 25 feet of entrances, operable windows, or outdoor-air intakes.
- 1.06 SPECIFICATION AND DRAWING CONVENTIONS:
- A. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
 - 1. Imperative mood and streamlined language are generally used in the Specifications. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.
 - 2. Specification requirements are to be performed by Contractor unless specifically stated otherwise.
 - B. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.
 - C. Drawing Coordination: Requirements for materials and products identified on Drawings are described in detail in the Specifications. One or more of the following are used on Drawings to identify materials and products:
 - 1. Terminology: Materials and products are identified by the typical generic terms used in the individual Specifications Sections.

2. Abbreviations: Materials and products are identified by abbreviations published as part of the U.S. National CAD Standard and scheduled on Drawings.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01 14 14
CONTROL OF WORK

PART 1 - GENERAL

1.01 WORK AND HOURS OF CONSTRUCTION

- A. Furnish equipment which will be efficient, appropriate, and large enough to secure a satisfactory quality of work and a rate of progress which will insure the completion of the work within the Contract Time. If at any time such plant appears to the Engineer or Owner to be inefficient, inappropriate, or insufficient for securing the quality of work required or for producing the rate of progress aforesaid, the Engineer or Owner may order the Contractor to increase the efficiency, change the character, or increase the plant equipment, and the Contractor shall conform to such order. Failure of the Engineer or Owner to give such order shall in no way relieve the Contractor of his obligations to secure the quality of the work and rate of progress required.
- B. See Section 01 11 00 for normal construction activity on-site work hours.

1.02 OCCUPYING PRIVATE LAND

- A. The Contractor shall not (except after written consent from the proper parties) enter or occupy with personnel, tools, materials, or equipment any land outside the rights of way or property of the Owner. A copy of the written consent shall be given to the Engineer and Owner.

1.03 PIPE LOCATIONS

- A. Exterior pipelines will be located substantially as indicated on the Drawings, but the right is reserved to the Owner, acting through the Engineer, to make such modifications in location as may be found desirable to avoid interference with existing structures or for other reasons. Where fittings, etc., are noted on the Drawings, such notation is for the Contractor's convenience and does not relieve him from laying and jointing different or additional items where required.
- B. Small interior piping is indicated diagrammatically on the Drawings, and the exact location is to be determined in the field. Piping shall be arranged in a neat, compact, and workmanlike manner, with a minimum of crossing and interlacing, so as not to interfere with equipment or access ways, and, in general, without diagonal runs.

1.04 DIMENSION OF EXISTING STRUCTURES

- A. The Contractor shall verify the dimensions and locations of existing structures in the field before the fabrication of any material or equipment which is dependent on the correctness of such information.

1.05 OPEN EXCAVATIONS

- A. All open excavations shall be adequately safeguarded by providing temporary barricades, fencing, caution signs, lights, and other means to prevent accidents to persons and damage to property, and in accordance with applicable occupational health and safety regulations. The Contractor shall, at his own expense, provide suitable and safe bridges and other crossings for accommodating travel by pedestrians and workmen. Bridges provided for access during construction shall be removed when no longer required. The length or size of excavation will be controlled by the particular surrounding conditions, but shall always be confined to the limits prescribed by the Engineer or Owner. If the excavation becomes a hazard, or if it excessively restricts traffic at any point, the Engineer or Owner may require special construction procedures such as limiting the length of the open trench, prohibiting stacking excavated material in the street, and requiring that the trench shall not remain open overnight.
- B. The Contractor shall take precautions to prevent injury to the public due to open trenches and provide appropriate lighting at night. All trenches, excavated material, equipment, or other obstacles which could be dangerous to the public shall be constructed in accordance with applicable rules and regulations.

1.06 TEST PITS

- A. Test pits for the purpose of locating underground pipeline or structures in advance of the construction shall be excavated and backfilled by the Contractor at the direction of the Engineer. Test pits shall be backfilled immediately after their purpose has been satisfied and the surface restored and maintained in a manner satisfactory to the Engineer.

1.07 INTERFERENCE WITH AND PROTECTION OF STREETS

- A. The Contractor shall not close or obstruct any portion of a street, road, or private way without obtaining permits therefor from the proper authorities. If any street, road or private way has the potential to be made unsafe by the Contractor's operations, prior to the Work, the Contractor shall make such repairs or provide such temporary ways or guards as shall be acceptable to the proper authorities.
- B. Streets, roads, private ways, and walks not closed shall be maintained passable and safe by the Contractor, who shall assume and have full responsibility for the adequacy and safety of provisions made therefor.
- C. The Contractor shall, at least 72 hours in advance, notify the Police and Fire Departments in writing, with a copy to the Engineer and Owner, if the closure of a street or road is necessary. The Contractor shall cooperate with the Police Department in the establishment of alternate routes and shall provide adequate detour signs, plainly marked and well lighted, in order to minimize confusion.

1.08 TRAFFIC CONTROL

- A. General:

1. Unless otherwise approved by the Engineer, Contractor shall maintain at least one 12-foot wide travel lane for each direction of travel at all times.
2. Full road and/or intersection closures will only be approved under extreme circumstances as determined by the Engineer. Street and/or lane closure fees may be assessed for closures determined to be for Contractor convenience in completing the Work.
3. If a lane, intersection, or road closure is approved by the Engineer, the Contractor shall be required to provide advance public notification. This shall be done using electronic message boards (variable message signs) at the beginning and end of each reach to be closed, and in all four directions at intersections, as well as flyers to the residents in the vicinity. The Contractor shall post both types of messages at least 7 days prior to closure.
4. A copy of the approved Traffic Control Plan shall be maintained on the job site at all times.
5. Unless otherwise approved by the Engineer, Contractor shall remove all traffic control devices from roadway at the end of each day. All advance warning signs not being used should be turned around until the traffic control placement the following day.
6. Contractor shall implement traffic control measures to safely and properly secure the work area, equipment, residents, and personnel throughout the duration of the project. This requirement also applies to portions of the work being performed by subcontractors.

B. University Avenue Crossing:

1. CONTRACTOR may adopt the prepared traffic control plan as shown on the Contract Drawings or may prepare a new traffic control plan for review. Traffic control plans for work within University Avenue shall conform to all requirements of UDOT Standard Specification 01554 Traffic Control and shall be submitted to and approved by UDOT.
2. CONTRACTOR may limit travel lane widths to 10-foot wide for each direction but shall maintain two lanes of travel in one direction and one lane of travel in the opposite direction. Full road closure will not be allowed.
3. CONTRACTOR shall provide advance public notification for work within University Avenue via electronic message boards (variable message signs) for north bound and south bound traffic. CONTRACTOR shall post messages at least 7 days prior to closure.
4. A copy of the approved Traffic Control Plan shall be maintained on the job site at all times.

5. Contractor shall implement traffic control measures to safely and properly secure the work area, equipment, residents, and personnel throughout the duration of the project. This requirement also applies to portions of the work being performed by subcontractors.

C. Intersections:

1. Use uniformed police officer when construction activities are impacting an operating signalized intersection.
2. Use of flaggers at a signalized intersection is permitted only when signals have been turned to red flash mode or are inoperable.
3. Control each approach by separate flaggers.
4. Flaggers can control only two lanes of approach traffic.
5. Third lane control permitted when left or right turn bays are present.
6. Coordinate all modifications to signal operations with Brian Torgersen, Provo City Traffic Engineer (801) 852-6745.
7. For unsignalized intersections – provide a certified flagger for each approach.
8. Existing left turn lanes may be used for through traffic movement when the need to reduce the through traffic to one lane at the approach to signalized intersections. Install appropriate channelization and install “No Left Turn” signs stating “Bus Exception” message.

9. ACCESS:

- a. CONTRACTOR shall provide access to all affected properties except for durations of less than 8 hours. In all cases:
- b. Provide alternate access whenever normal access is blocked and an alternate access method is possible.
- c. Notify property owners 48 hours in advance of change or loss of access detailing duration and frequency of access closures.

10. PARKING RESTRICTIONS:

- a. CONTRACTOR shall be responsible to notify residents and/or businesses of any necessary parking restrictions that may be required to complete the Work.
- b. CONTRACTOR shall post “NO PARKING” signs every 50 feet 24 hours in advance of the anticipated need for parking restrictions.

11. PUBLIC TRANSIT:

- a. CONTRACTOR shall contact the Utah Transit Authority (UTA) and coordinate necessary alternations in UTA's bus service. Details of alternate bus routes are to be submitted with the Traffic Control Plan.
 - b. CONTRACTOR shall keep bus stops open and clear of debris and minimize disruption to current bus services in and around bus stops.
12. MOMENTARY PARTIAL OR COMPLETE LANE CLOSURE AUTHORIZATION (WITHOUT PERMIT):
- a. Provide flagger when work momentarily affects travel lanes. Example: A backhoe maneuvering in a travel lane outside of the construction work zone.
 - b. Activities requiring momentary partial or complete lane closures shall be kept to a minimum. Lane closure fees may be assessed as determined appropriate by the ENGINEER for excessive momentary closures.
13. TRAFFIC CONTROL PLAN
- a. CONTRACTOR shall develop and submit a Traffic Control Plan which satisfies OWNER's requirements and shall conform to the requirements of this section and the requirements, limitations, and phasing identified in Section 01 11 00S. Traffic Control Plan to be created using the recommendations and guidelines outlined in the following resources. Resolve discrepancies between resources in descending order as shown:
 - (1) MUTCD.
 - (2) Work Zone Traffic Control Guide
 - (3) ATSSA
 - b. CONTRACTOR shall be responsible to provide a Traffic Control Plan for all phases, segments, and portions of the WORK including items of the WORK performed by Subcontractors and work within University Avenue.
 - c. The Traffic Control Plan shall be prepared using CAD software showing the appropriate scale and space relationship between traffic control devices and intersections, high volume driveways, and other pertinent roadway features.
 - d. OWNER may require that the Traffic Control Plan be produced, signed, and sealed by a professional engineer licensed in the State of Utah at no additional cost to the OWNER.
 - e. CONTRACTOR shall coordinate with Brian Torgersen, Provo City Traffic Engineer, (801) 852-6745, in the preparation and implementation of the Traffic Control Plan.

- f. Include the following documentation as part of the traffic control plan:
 - (1) Written description and phasing.
 - (2) Drawing showing phasing (if required for clarity)
 - (3) Drawing showing placement of traffic control devices.
 - g. Show how to move pedestrians through or around the Work site.
 - h. Show how traffic control at signalized intersections will be addressed.
 - i. Provide concrete barrier or other positive protection for workers and all hazards located within the AASHTO clear zone for approach traffic.
 - j. Meet grade, slope and protection requirements of the Americans with Disabilities Act (ADA).
14. TRAFFIC CONTROL TECHNICIAN
- a. Certified by UDOT, ATSSA, or Associated General Contractors (AGC).
 - b. Authority
 - (1) Obtains and uses all labor, equipment, and materials necessary to maintain traffic control.
 - (2) Changes traffic control operations according to the approved traffic control plan.
 - c. Responsibilities and Duties
 - (1) Oversees all traffic control operations.
 - (2) Will be present and active participant during the installation, maintenance, and removal of Temporary Traffic Control Devices.
 - (3) Implements the Traffic Control Plan.
 - (4) Remains available 24 hours a day, seven days a week and can be on-site within 30 minutes of notification.
 - (5) Corrects deficiencies immediately upon verbal or written notification from Engineer or his representative.
 - (6) Document the traffic control activities and inspections on a form acceptable to the Engineer. Inspect at least four times each day with at least one of the inspections conducted during nighttime hours:

- (a) Before beginning of shift
 - (b) At mid-shift
 - (c) Half-hour after shift ends
 - (d) At midpoint of the off-shift period
- (7) Coordinate project traffic control with emergency services and local law enforcement agencies.
 - (8) Inspect and document traffic control inspections twice each day when no construction work is being done.
 - (a) Once during daylight hours and once during nighttime hours.
 - (b) Conduct inspections a minimum of eight hours apart.
 - (9) Submit traffic control activities and inspection forms each week on a day and time acceptable to the Engineer.
 - (10) Monitor traffic queue lengths and adjust advanced warning signs to provide adequate warning to the actual back of queue resulting from construction activities.

15. FLAGGER

- a. Certified by ATSSA, AGC, or UDOT.
- b. Equipment:
 - (1) 24" X 24" "Stop/Slow" sign.
 - (2) 6" to 8" long red wand for night flagging.
 - (3) Light plant for night flagging.
- c. Clothing:
 - (1) Clothed; full length pants and long or short sleeved shirt.
 - (2) Hard toed shoes.
 - (3) Lime green, orange, or red-orange hardhat and vest.
 - (4) Night clothing to be reflectorized.

1.09 CARE AND PROTECTION OF PROPERTY

- A. The Contractor shall be responsible for the preservation of all public and private property, and shall use every precaution necessary to prevent damage thereto. If any direct or indirect damage is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work on the part of the Contractor, such property shall be restored by the Contractor, at his expense, to a condition similar or equal to that existing before the damage was done, or he shall make good the damage in other manner acceptable to the Engineer and Owner.

1.10 INTERFERENCE WITH EXISTING WORKS

- A. The Contractor shall at all times conduct his operations so as to interfere as little as possible with existing works. The Contractor shall develop a program, in cooperation with the Engineer and interested officials, which shall provide for the construction and putting into service of the new works in the most orderly manner possible. This program shall be adhered to except as deviations therefrom are expressly permitted. All work of connecting with, cutting into, and reconstructing existing pipes or structures shall be planned to interfere with the operation of the existing facilities for the shortest possible time when the demands on the facilities best permit such interference, even though it may be necessary to work outside of normal working hours to meet these requirements. Before starting work which will interfere with the operation of existing facilities, the Contractor shall do all possible preparatory work and shall see that all tools, materials, and equipment are made ready and at hand.
- B. The Contractor shall make such minor modifications in the work relating to existing structures as may be necessary, without additional compensation.

1.11 PROTECTION AND RELOCATION OF EXISTING STRUCTURES AND UTILITIES

- A. The Contractor shall assume full responsibility for the protection of all buildings, structures, and utilities, public or private, including poles, signs, services to buildings, utilities in the street, gas pipes, water pipes, hydrants, sewers, drains, and electric and telephone cables, whether or not they are shown on the Drawings. The Contractor shall carefully support and protect all such structures and utilities from injury of any kind. Any damage resulting from the Contractor's operations shall be repaired by him at his expense.
- B. The Contractor shall bear full responsibility for obtaining all locations of underground structures and utilities (including existing water services, drain lines, and sewers). Services to buildings shall be maintained, and all costs or charges resulting from damage thereto shall be paid by the Contractor.
- C. Protection and temporary removal and replacement of existing utilities and structures as described in this Section shall be a part of the work under the Contract and all costs in connection therewith shall be included in the Total Price Bid in the Bid Form.

1.12 INSPECTION OF WORK AWAY FROM THE SITE

- A. If work to be done away from the construction site is to be inspected on behalf of the Owner during its fabrication, manufacture, or testing, or before shipment, the Contractor shall give notice to the Engineer of the place and time where such fabrication, manufacture, testing, or shipping is to be done. Such notice shall be in writing and delivered to the Engineer in ample time so that the necessary arrangements for the inspection can be made.

1.13 COOPERATION WITHIN THIS CONTRACT

- A. All firms or persons authorized to perform any work under this Contract shall cooperate with the Owner, Engineer, and General Contractor and his Subcontractors or trades, and shall assist in incorporating the work of other trades where necessary or required.
- B. Cutting and patching, drilling and fitting shall be carried out where required by the trade or subcontractor having jurisdiction, unless otherwise indicated herein or recommended by the Engineer.

1.14 CLEANUP AND DISPOSAL OF EXCESS MATERIAL

- A. During the course of the work, the Contractor shall keep the site of his operations in as clean and as neat a condition as is possible. He shall dispose of all residue resulting from the construction work and, at the conclusion of the work, he shall remove and haul away any surplus excavation materials, broken pavement, lumber, equipment, temporary structures, and any other refuse remaining from the construction operations, and shall leave the entire site of the work in a neat and orderly condition.
- B. In order to prevent environmental pollution arising from the construction activities related to the performance of this Contract, the Contractor and his subcontractors shall comply with all applicable Federal, State, and local laws, and regulations concerning site management, waste material disposal, as well as the specific requirements stated in this Section and elsewhere in the Specifications.
- C. The Contractor is advised that the disposal of excess excavated material in wetlands, stream corridors, and plains is strictly prohibited even if the permission of the property owner is obtained. Any violation of this restriction by the Contractor or any person employed by him, will be brought to the immediate attention of the responsible regulatory agencies, with a request that appropriate action be taken against the offending parties. Therefore, the Contractor will be required to remove the fill at his own expense and restore the area impacted.
- D. Obtain prior approval from the Owner and Engineer for any stockpiling of material onsite.

PART 2 - PRODUCTS

2.1 PAVEMENT MARKINGS, SIGNS, BARRICADES

- A. MUTCD.
- B. Channelizing Devices: Crash worthy plastic cones, drums and barricades.
 - 1. Only drums, barricades, and vertical panels will be allowed for nighttime use. No cones will be allowed for nighttime use.
- C. Reflective Sheeting: ASTM D 4956.
- D. Pavement Markings: Section 32 17 23.
 - 1. Temporary striping: by CONTRATOR
 - 2. Permanent striping: by CONTRACTOR
 - a. ENGINEER will provide layout for new pavement striping where striping has been completely removed.
 - b. CONTRACTOR shall be responsible to provide traffic control for ENGINEER during striping layout operations
 - 3. Permanent rumble strips: by CONTRACTOR
 - a. To follow installation of permanent striping and requires restriping following grinding of rumble strips.

PART 3 - EXECUTION

3.1 FLAGGING

- A. MUTCD
- B. ATSSA

3.2 TRAFFIC CONTROL DEVICES

- A. Install traffic control devices before work activities begin.
- B. Maintain devices to ensure proper, continuous function.
- C. Wash devices weekly unless conditions warrant more frequent cleaning.

- D. Replace damaged devices missing any part of the message or background.
- E. Remove when no longer needed.
- F. Concrete barriers are not to be used as road closure devices.

END OF SECTION

SECTION 01 21 00

ALLOWANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Section includes administrative and procedural requirements governing allowances.
 - 1. Certain items are specified in the Contract Documents by allowances. Allowances have been established in lieu of additional requirements and to defer selection of actual materials and equipment to a later date when direction will be provided to Contractor.
- B. Types of allowances include the following:
 - 1. Cash allowances for laboratory equipment.
 - 2. Cash allowances for tools.

1.02 SELECTION AND PURCHASE:

- A. At the earliest practical date after award of the Contract, advise Engineer of the date when final selection and purchase of each product or system described by an allowance must be completed to avoid delaying the Work.
- B. At Engineer's request, obtain proposals for each allowance for use in making final selections. Include recommendations that are relevant to performing the Work.
- C. Purchase products and systems selected by Engineer from the designated supplier.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Submit proposals for purchase of products or systems included in allowances.
- C. Coordinate and process submittals for allowance items in same manner as for other portions of the Work.

1.04 COORDINATION:

- A. Coordinate allowance items with other portions of the Work. Furnish templates as required to coordinate installation.

1.05 CASH ALLOWANCES FOR EQUIPMENT OR MATERIALS:

A. Amount of each allowance for Work specified see Section 3.03.

B. Engineer's Duties:

1. Consult with Contractor in consideration of equipment or material and suppliers or installers.
2. Make selection in consultation with Owner. Obtain Owner's written decision, designating following as applicable.
 - a. Material, equipment, model, and finish.
 - b. Accessories and attachments.
 - c. Supplier and installer.
 - d. Cost to Contractor, delivered to site or installed.
 - e. Manufacturer's warranties.
3. Transmit Owner's written decision to Contractor.

C. Contractor's Duties:

1. At earliest feasible date after award of Contract, advise Engineer of scheduled date when final selection of material or equipment described by each allowance must be accomplished in order to avoid delays in performance of Work.
2. Assist Engineer and Owner in determining qualified suppliers or installers.
3. Obtain proposals from suppliers and installers when requested by Engineer.
4. Make appropriate recommendations for consideration of Owner and Engineer.
5. Notify Engineer promptly of following:
 - a. Reasonable objections Contractor may have against supplier or installer under consideration.
 - b. Effect on construction schedule anticipated by selections under consideration.
6. On notification of selection, execute purchase agreement with designated supplier.
7. Arrange for and process Shop Drawings, product data, and samples as required.
8. Make arrangements for delivery.

9. Upon delivery, inspect materials or equipment for damage or defects.
 10. Submit claims for transportation damage.
 11. Install and finish materials or equipment as directed by Owner.
- D. Adjustment of Costs:
1. If cost is more or less than specified allowance, Contract Price will be adjusted by Change Order.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine products covered by an allowance promptly on delivery for damage or defects. Return damaged or defective products to manufacturer for replacement.

3.02 PREPARATION:

- A. Coordinate materials and their installation for each allowance with related materials and installations to ensure that each allowance item is completely integrated and interfaced with related work.

3.03 SCHEDULE OF ALLOWANCES:

- A. Lump-Sum Allowance:

1. Include lump sum of \$250,000 for purchase and supply of laboratory equipment.
2. Include lump sum of \$20,000 for purchase and supply of tools.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 01 25 00

SUBSTITUTION PROCEDURES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Section includes administrative and procedural requirements for substitutions.

1.02 DEFINITIONS:

- A. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor.
 - 1. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
 - 2. Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Substitution Requests: Submit three copies of each request for consideration. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.
 - 1. Substitution Request Form: Use Form 01 25 00-1 to request substitution.
 - 2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:
 - a. Justification for use of the proposed equivalent item(s), including evidence, as applicable, that Contract specified material, product or equipment is unobtainable or unobtainable within an acceptable time for Contract completion.
 - b. Statement indicating why specified product or fabrication or installation cannot be provided, if applicable. If the Contractor is proposing the substitution because of unavailability of the product, submit a letter from the manufacturer stating the product is unavailable with an explanation of why it is unavailable with the form 01 25 00-1

- c. Coordination information, including a list of changes or revisions needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
- d. Detailed comparison of qualities of proposed substitution with those of the Work specified. Include annotated copy of applicable Specification Section. Significant qualities may include attributes such as performance, weight, size, electrical characteristics, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated and specified. Indicate deviations, if any, from the Work specified.
- e. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
- f. Samples, where applicable or requested.
- g. Certificates and qualification data, where applicable or requested.
- h. List of similar installations for completed projects with project names and addresses and names, telephone numbers and addresses of engineers and owners.
- i. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
- j. Research reports evidencing compliance with building code in effect for Project.
- k. Detailed comparison of Contractor's construction schedule using proposed substitution with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
- l. Cost information, including a proposal of change, if any, in the Contract Sum.
- m. A prediction of any effects the proposed change will have on operation and maintenance costs, where applicable.
- n. Contractor's certification that proposed substitution complies with requirements in the Contract Documents except as indicated in substitution request, is compatible with related materials, and is intended for applications indicated.

- o. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.
 - 3. Engineer's Action: If necessary, Engineer will request additional information or documentation for evaluation within seven days of receipt of a request for substitution. Engineer will notify Contractor of acceptance or rejection of proposed substitution within 15 days of receipt of request, or seven days of receipt of additional information or documentation, whichever is later.
 - a. Forms of Acceptance: Change Order, Construction Change Directive, or Engineer's Supplemental Instructions for minor changes in the Work.
 - b. Use product specified if Engineer does not issue a decision on use of a proposed substitution within time allocated.

1.04 ACCEPTABLE EQUIVALENT PRODUCTS, MATERIALS AND EQUIPMENT:

- A. Any other product the contractor wants to substitute must follow the requirements of this Section.
- B. If the Contractor chooses to substitute equipment other than a named manufacturer(s), any additional costs or time required to accommodate such equipment shall be made without a change in the Contract Price or Contract Time and at no additional cost to the Owner.

1.05 MATERIAL AND WORKMANSHIP:

- A. Whenever a material, article, system, or sub-system is specified or described by using the name and/or model of a proprietary product or trademark or the name of the manufacturer or vendor, the specified item shall establish the type, function, and quality required; it shall be understood that the words "or approved equivalent" are implied whether or not they follow the proprietary enumeration.
- B. The Engineer reserves the right to determine when proprietary items have no equivalency, and when uniformity of operations, interchangeability of parts, standard parts inventory, etc., are in Owner's best interest.
- C. Requests for review of equivalency will be considered upon submission of sufficient information as described herein, to allow complete review.
- D. Such requests will not be accepted from anyone other than the Contractor. Such submission must be made prior to purchase, fabrication, manufacture, or use of the equivalent items under consideration.
- E. The Contractor is responsible for all delays caused by its failure to submit complete and accurate information with any request for approval of any material, article, system, or subsystem, as an equivalent.

1. Contractor Risk:
 - a. If the Contractor includes in his bid or later proposes any material, product, or equipment that he considers equivalent to that specified, the Contractor assumes all risk of any sort associated with acceptance or rejection of proposed equivalent items.
 - b. The Contractor shall have no right to make claim based upon his bid that includes a proposed equivalent item(s) of work which resulted in a lower bid amount for said item(s) or lower total bid.
2. Equivalency:
 - a. An item will be considered equivalent to the item specified if:
 - (1) It is equal or better in design and strength in all subparts, quality, reliability and durability, operation, maintenance, and serviceability, as applicable; and
 - (2) It is equal or better in specified parameters in performance in all respects for the specific function(s) indicated in the contract.
 - b. Engineer shall make final determination of equivalence.
3. Supplemental Requirements:
 - a. The time associated with equivalency review will be paid by the Contractor.
 - b. Any tests required by the Engineer to establish quality and performance standards shall be promptly conducted by or through the Contractor at no additional cost to the Owner.
 - c. The Contractor shall submit any additional data requested by the Engineer for the equivalency review.
 - d. The Contractor shall satisfactorily accomplish all changes, including any engineering associated with use of equivalent items, at no additional cost to the Owner.
 - e. The Contractor shall have no right of appeal to any decision rejecting the equivalency of any item.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Compatibility of Substitutions: Investigate and document compatibility of proposed substitution with related products and materials. Engage a qualified testing agency to

perform compatibility tests recommended by manufacturers at no cost to the Engineer or Owner.

1.07 PROCEDURES:

- A. Coordination: Revise or adjust affected work as necessary to integrate work of the approved substitutions.

PART 2 - PRODUCTS

2.01 SUBSTITUTIONS:

- A. Substitutions for Cause: Submit requests for substitution immediately on discovery of need for change, but not later than 15 days prior to time required for preparation and review of related submittals.

- 1. Conditions: Engineer will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, Engineer will return requests without action, except to record noncompliance with these requirements:

- a. Requested substitution is consistent with the Contract Documents and will produce specified and indicated results.
- b. Requested substitution provides sustainable design characteristics that specified product provided.
- c. Substitution request is fully documented and properly submitted.
- d. Requested substitution will not negatively affect Contractor's construction schedule.
- e. Requested substitution has received necessary approvals of authorities having jurisdiction.
- f. Requested substitution is compatible with other portions of the Work.
- g. Requested substitution has been coordinated with other portions of the Work.
- h. Requested substitution provides specified warranty.
- i. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

- B. Substitutions for Convenience: Not allowed

PART 3 - EXECUTION

3.01 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

Form 01 25 00-1
SUBSTITUTION REQUEST

The Undersigned certifies:

- Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
- Same warranty will be furnished for proposed substitution as for specified product.
- Same maintenance service and source of replacement parts, as applicable, is available.
- Proposed substitution will have no adverse effect on other trades and will not affect or delay progress schedule.
- Claims for additional costs related to accepted substitution which may subsequently become apparent are to be waived.
- Proposed substitution does not affect dimensions and functional clearances.
- Payment will be made for changes to design, including Engineer design, detailing, and construction costs caused by the substitution.
- Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitted by: _____

Signed by: _____

Firm: _____

Address: _____

Telephone: _____

Attachments: _____

REVIEW AND ACTION

- ☐ Substitution approved – Make submittals in accordance with Specification Section 01 25 00.
- ☐ Substitution approved as noted – Make submittals in accordance with Specification Section 01 25 00.
- ☐ Substitution rejected – Use specified materials.
- ☐ Substitution Request received too late – Use specified materials.

Signed by: _____ Date: _____

Additional Comments: ☐ Contractor ☐ Subcontractor ☐ Supplier ☐ Manufacturer ☐ Engineer ☐ Other: _____

Form 01 25 00-1 (Continued)
SUBSTITUTION REQUEST

Project: _____	Substitution Request Number: _____
_____	From: _____
To: _____	Date: _____
_____	Engineer Project Number: _____
Re: _____	Contract For: _____
Specification Title: _____	Description: _____
Section: _____ Page: _____	Article/Paragraph: _____
Proposed Substitution: _____	
Manufacturer: _____	Address: _____ Phone: _____
Trade Name: _____	Model No. _____
Installer: _____	Address: _____ Phone: _____
History: <input type="checkbox"/> New product <input type="checkbox"/> 1-4 years old <input type="checkbox"/> 5-10 years <input type="checkbox"/> More than 10 years old	
Differences between proposed substitution and specified product: _____	

<input type="checkbox"/> Point-by-point comparative data attached – REQUIRED BY Engineer	
Reason for not providing specified item: _____	

Similar Installation:	
Project: _____	Engineer/Architect: _____
Address: _____	Owner: _____
_____	Date Installed: _____
Proposed substitution affects other part of Work: <input type="checkbox"/> No <input type="checkbox"/> Yes, explain _____	

Savings to Owner for accepting substitution: _____	
Proposed substitution changes Contract Time: <input type="checkbox"/> No <input type="checkbox"/> Yes [Add] [Deduct] _____ days.	
Supporting Data Attached: <input type="checkbox"/> Drawings <input type="checkbox"/> Product Data <input type="checkbox"/> Samples <input type="checkbox"/> Tests <input type="checkbox"/> Reports _____	

END OF SECTION

SECTION 01 31 19
PROJECT MEETINGS

PART 1 - GENERAL

1.01 CONTRACTORS RESPONSIBILITY:

- A. Contractor shall schedule and administer meetings with their own staff and/or other contractors, construction foremen's meetings, and specially called meetings with these parties throughout progress of Work. Contractor shall:
 - 1. Prepare agenda for meetings.
 - 2. Distribute written notice of specially called meetings minimum of one working day(s) in advance of meeting date.
 - 3. Make physical arrangements for meetings.
 - 4. Preside at meetings.
 - 5. Record minutes; include significant proceedings and decisions.
 - 6. Prepare formal minutes and distribute within two working days after each meeting to the following:
 - a. Meeting participants.
 - b. Parties affected by decisions made at meeting.
 - c. Engineer and Owner - furnish both with three copies of minutes.
- B. Representatives of Contractor, Subcontractors, and Suppliers attending meetings shall be qualified and authorized to act on behalf of entity each represents.
- C. Owner and Engineer may attend meetings.

1.02 PRECONSTRUCTION CONFERENCE:

- A. Attend a pre-construction meeting.
- B. Engineer will preside at the preconstruction conference and will arrange for keeping the minutes and distributing the minutes to all persons in attendance.
- C. The location of the conference will be determined by the Owner. Contractor should plan on the conference taking no less than 4 hours.

- D. The time of the meeting will be determined by the Owner but will be after the Notice of Award is issued and not later than fifteen (15) days after the Notice to Proceed is issued.
- E. The Owner, Engineer, representatives of utility companies, the Contractor's project manager and superintendent, and representatives from major Subcontractors and Suppliers shall attend the meeting.
- F. Contractor shall provide and be prepared to discuss:
 - 1. Preliminary construction schedule per Section 01 32 17 "Construction Progress Schedule".
 - 2. Preliminary submittal schedule per Section 01 33 00 "Submittals".
 - 3. Schedule of values and anticipated schedule of payments.
 - 4. List of Subcontractors and Suppliers.
 - 5. Contractor's organizational chart as it relates to this project.
 - 6. Letter indicating the agents of authority for the Contractor and the limit of that authority with respect to the execution of legal documents, contract modifications and payment requests.

1.03 PROGRESS MEETINGS

- A. Attend meetings with the Engineer and Owner.
 - 1. Meet on a bi-weekly basis or as requested by the Engineer to discuss the project.
 - 2. Meet at the project site or other location as designated by the Engineer.
 - 3. Contractor's superintendent and other key personnel are to attend the meeting. Other individuals may be requested to attend to discuss specific matters.
- B. Engineer shall preside at the meetings and provide for keeping and distribution of the minutes. The purpose of the meetings will be to review the progress of the work, maintain coordination of efforts, discuss changes in scheduling, and resolve other problems which may develop. Provide information as requested by the Engineer or Owner concerning this project.
 - 1. Prepare to discuss:
 - a. Status of overall project schedule.
 - b. Contractor's detailed schedule for the next month.
 - c. Anticipated delivery dates for equipment.

- d. Coordination with the Owner.
 - e. Status of submittals.
 - f. Information or clarification of the Contract Documents.
 - g. Claims and proposed modifications to the contract.
 - h. Field observations, problems, or conflicts.
 - i. Maintenance of quality standards.
- 2. Notify the Engineer of any specific items to be discussed a minimum of one week prior to the meeting.
- C. Review minutes of meetings and notify the Engineer of any discrepancies within ten days of the date of the memorandum.
- 1. Following that date, the minutes will stand as shown or as corrected.
 - 2. Corrections will be reflected in the minutes of the following meeting. Issues discussed will be documented and old issues will remain on minutes of subsequent meetings until the issue is resolved.

1.04 PRE-SUBMITTAL AND PRE-INSTALLATION MEETINGS

- A. Attend pre-submittal and pre-installation meetings as required in the individual technical specifications or as determined necessary by the Engineer (for example, instrumentation, roofing, concrete mix design, etc.).
- B. The location of the meeting will be determined by the Engineer.
- C. The time of the meeting will be determined by the Contractor when ready to proceed with the associated work, subject to submission of a Notification by Contractor form and acceptance by the Engineer and Owner of the proposed time.
- D. The Owner, Engineer, the Contractor's project manager and superintendent, and representatives from affected Subcontractors and Suppliers shall attend the meeting.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01 31 24

INTERNET BASED CONSTRUCTION MANAGEMENT SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. The Owner will utilize the Internet-based project delivery management system Procore to manage this project.
- B. The project website will provide server space and secured access to staff members representing the Owner, Engineer, and Contractor. Each user will have a separate log-in name and password to access the website.
 - 1. Upon receipt of Notice of Award, Contractor to designate the lead person who will automatically receive notifications when responses are made to contractor postings.
 - 2. Instruction for login and use of system will be provided prior to preconstruction meeting.
- C. Contract management related documents will be submitted, tracked, responded to, and made available to the Owner, Engineer and Contractor through the management system.

1.02 REQUIREMENTS

- A. The Contractor will be required to make all submittals in electronic format by utilizing the designated construction management system. Process will be discussed at the pre-construction meeting.
- B. The website includes a secured document management system for storing and making available to the project team the following:
 - 1. Ability to store files and correspondence.
 - 2. Latest drawings and specifications.
 - 3. Project progress photos.

All electronic documents are considered record on file upon system receipt.

- C. The website will include the following database driven applications. The system is designed to inform team members regarding new or updated documents and automatic task assignment and overdue notifications. The following items shall be entered, submitted, tracked, and responded to on-line:
 - 1. Document Management

2. Construction Schedule
3. Meeting Minutes
4. RFIs (Requests for Information)
5. Submittals
6. Owner Inspector Daily Field Report.
7. Contractor's Site Visit Reports

1.03 ARCHIVES

- A. Web based project delivery management application shall be capable of archiving all files on the website.
- B. All data from the website, such as RFIs, submittals, etc. will be available in the archive.
- C. The project website will provide server space and secured access to staff members representing the Owner, Engineer, and Contractor. Each user will have a separate log-in name and password to access the website.
 1. Upon receipt of Notice of Award, Contractor to designate the lead person who will automatically receive notifications when responses are made to contractor postings.
 2. Instruction for login and use of system will be provided prior to preconstruction meeting.
- D. Contract management related documents will be submitted, tracked, responded to, and made available to the Owner, Engineer and Contractor through the management system.

1.04 REQUIREMENTS

- A. The Contractor will be required to make all submittals in electronic format by utilizing the designated construction management system. Process will be discussed at the pre-construction meeting.
- B. The website includes a secured document management system for storing and making available to the project team the following:
 1. Ability to store files and correspondence.
 2. Latest drawings and specifications.
 3. Project progress photos.All electronic documents are considered record on file upon system receipt.

- C. The website will include the following database driven applications. The system is designed to inform team members regarding new or updated documents and automatic task assignment and overdue notifications. The following items shall be entered, submitted, tracked, and responded to on-line:

1. Document Management
2. Construction Schedule
3. Meeting Minutes
4. RFIs (Requests for Information)
5. Submittals
6. Owner Inspector Daily Field Report.
7. Contractor's Site Visit Reports

PART 2 - PRODUCTS

2.01 SOFTWARE

- A. Procore Technologies, Inc.

PART 3 - EXECUTION

3.01 ORIENTATION

- A. Contractor will receive system orientation by email. Orientation email will contain login instructions, video tutorials, user guide and access to system provided online training resources. Additional training can be done at the request of Contractor at no additional expense to the Contractor.

3.02 SUPPORT

- A. Contractor shall contact Engineer for initial system support. Engineer will determine if Project Controls is to be contacted for further support. System support is provided at no additional expense to Contractor.

3.03 OPERATION

- A. Contractor shall maintain high speed access to the internet for the Contractor, Engineer, and Owner to have access to and use of system at the jobsite trailers as well as on mobile devices.

3.04 DURATION

- A. The website will be active for the duration of project delivery and a minimum of 3 months past final completion at which time the project file will be archived.

3.05 ARCHIVES

- A. All files on the website will be archived at the end of the project. The archive file will be made available upon request by Contractor no sooner than 3 months past final completion.

END OF SECTION

SECTION 01 32 17

CONSTRUCTION PROGRESS SCHEDULES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide Construction Progress Schedules as indicated and in compliance with Contract Documents.
- B. Summary:
 - 1. Section includes administrative and procedural requirements for planning, monitoring, and documenting the progress of construction during performance of the Work, including the following:
 - a. Startup construction schedule.
 - b. Contractor's construction schedule.
 - c. Construction schedule updating reports.
 - d. Daily construction reports.
 - e. Material location reports.
 - f. Site condition reports.
 - g. Special reports.
- C. The Contractor has the obligation and responsibility at all times to plan and monitor all of its activities, anticipating and scheduling its staff, materials, plant and Work methods in a manner that is likely to ensure completion of the Work in accordance with the terms and conditions of the Contract and at a rate that will allow it to be completed within the Contract Time.

1.02 DEFINITIONS:

- A. Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities included in a construction schedule consume time and resources.
 - 1. Critical Activity: An activity on the critical path that must start and finish on the planned early start and finish times.
 - 2. Predecessor Activity: An activity that precedes another activity in the network.

- 3. Successor Activity: An activity that follows another activity in the network.
- B. Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Project duration and contains no float.
- C. Event: The starting or ending point of an activity.
- D. Float: The measure of leeway in starting and completing an activity.
 - 1. Float time is not for the exclusive use or benefit of either Owner or Contractor, but is a jointly owned, expiring Project resource available to both parties as needed to meet schedule milestones and Contract completion date.
 - 2. Free float is the amount of time an activity can be delayed without adversely affecting the early start of the successor activity.
 - 3. Total float is the measure of leeway in starting or completing an activity without adversely affecting the planned Project completion date.
 - 4. Use of float suppression techniques such as software constraints, preferential sequencing, special lead/lag logic restraints, extended activity times, or imposed dates, other than as required by the Contract, shall be cause for the rejection of any schedule submitted by the Contractor.
- E. Resource Loading: The allocation of manpower and equipment necessary for the completion of an activity as scheduled.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Format for Submittals: Submit required submittals in the following format:
 - 1. Working electronic copy of schedule file, where indicated.
 - 2. PDF electronic file.
- C. Startup construction schedule.
 - 1. Within 15 days after execution of the AGREEMENT, submit 3 copies of a preliminary schedule indicating planned operations during first 60 days. Include cost of activities expected to be completed before submission and acceptance of the complete schedule.
- D. Startup Network Diagram: Of size required to display entire network for entire construction period. Show logic ties for activities.

1. Within 30 days after execution of the AGREEMENT, submit 3 copies of the complete network analysis system. After review, submit 3 copies of the mutually acceptable system.
 - E. Contractor's Construction Schedule: Initial schedule, of size required to display entire schedule for entire construction period.
 - F. Construction Progress Schedule and Updating Reports: Submit with Applications for Payment.
 - G. Daily Construction Reports: Submit at weekly intervals.
 - H. Material Location Reports: Submit at weekly intervals.
 - I. Site Condition Reports: Submit at time of discovery of differing conditions.
 - J. Special Reports: Submit at time of unusual event.
- 1.04 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
- 1.05 COORDINATION:
- A. Coordinate preparation and processing of schedules and reports with performance of construction activities and with scheduling and reporting of separate contractors.
 - B. Coordinate Contractor's construction schedule with the schedule of values, submittal schedule, progress reports, payment requests, and other required schedules and reports.
 1. Secure time commitments for performing critical elements of the Work from entities involved.
 2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

PART 2 - PRODUCTS

2.01 CONTRACTOR'S CONSTRUCTION SCHEDULE, GENERAL:

- A. Contractor shall maintain an overall project schedule which shall include all construction activities. Schedule shall demonstrate major milestones for the overall Contract.
- B. Time Frame: Extend schedule from date established for the Notice of Award to date of final completion.
 1. Contract completion date shall not be changed by submission of a schedule that shows an early completion date, unless specifically authorized by Change Order.

C. Activities: Treat each separate area as a separate numbered activity for each main element of the Work. Comply with the following:

1. Activity Duration: Define activities to sufficiently describe the tasks involved in the work, include procurement, long lead wait times, and delivery of equipment. Add additional activities and details as requested by Engineer or Owner. The durations shall be determined based upon resource planning under contractually-defined on-site work conditions. The Engineer may require that the duration of major activities be calculated by the scheduling software on the basis of the planned rate of daily production. In calculating activity durations, normal inclement weather shall be considered.
2. Procurement Activities: Include procurement process activities for all long lead items and major equipment items, requiring a cycle of more than 90 days, as separate activities in schedule. Procurement cycle activities include, but are not limited to, submittals, acceptance, purchasing, fabrication, and delivery.
3. Submittal Review Time: Include review and resubmittal times indicated in Division 01 Section "Submittal" in schedule. Coordinate submittal review times in Contractor's construction schedule with submittal schedule.
4. Startup and Testing Time: Include startup and testing time appropriate for each individual process or piece of equipment.
5. Substantial Completion: Indicate completion in advance of date established for Substantial Completion, and allow no fewer than 30 days for Engineer's administrative procedures necessary for certification of Substantial Completion.
6. Punch List and Final Completion: Include not more than 60 days for completion of punch list items and final completion.

D. Constraints: Include constraints and work restrictions indicated in the Contract Documents and as follows in schedule, and show how the sequence of the Work is affected.

1. Phasing: Arrange list of activities on schedule by phase.
2. Work Under More Than One Contract: Include a separate activity for each contract.
3. Work by Owner: Include a separate activity for each portion of the Work performed by Owner.
4. Products Ordered in Advance: Include a separate activity for each product. Include delivery date indicated in Division 01 Section "Summary of Work." Delivery dates indicated stipulate the earliest possible delivery date.

5. Owner-Furnished Products: Include a separate activity for each product. Include delivery date indicated in Division 01 Section "Summary of Work." Delivery dates indicated stipulate the earliest possible delivery date.
6. Work Restrictions: Show the effect of the following items on the schedule:
 - a. Coordination with existing construction.
 - b. Limitations of continued occupancies.
 - c. Uninterruptible services.
 - d. Partial occupancy before Substantial Completion.
 - e. Use of premises restrictions.
 - f. Provisions for future construction.
 - g. Seasonal variations and inclement weather.
 - h. Environmental control.
 - i. Specified work sequences and constraints.
7. Work Stages: Indicate important stages of construction for each major portion of the Work, including, but not limited to, the following:
 - a. Subcontract awards.
 - b. Submittals.
 - c. Purchases.
 - d. Mockups.
 - e. Fabrication.
 - f. Sample testing.
 - g. Deliveries.
 - h. Installation.
 - i. Functional testing.
 - j. Start-up.
 - k. Commissioning.

- l. Performance testing.
 - m. Training
 - n. Tests and inspections.
 - o. Adjusting.
 - p. Curing.
 - q. Startup and placement into final use and operation.
 - r. Project closeout and final cleaning.
 - s. Demobilization.
- E. Milestones: Include milestones indicated in the Contract Documents in schedule, including, but not limited to, the Notice to Proceed, Substantial Completion, and final completion.
- F. Upcoming Work Summary: Prepare summary report indicating activities scheduled to occur or commence prior to submittal of next schedule update. Summarize the following issues:
 - 1. Unresolved issues.
 - 2. Unanswered Requests for Information.
 - 3. Rejected or unreturned submittals.
 - 4. Notations on returned submittals.
 - 5. Pending modifications affecting the Work and Contract Time.
- G. Recovery Schedule:
 - 1. When periodic update indicates critical path or major milestones of the Work is thirty or more calendar days behind the current accepted construction schedule and directed by owner, submit a separate recovery schedule indicating means by which Contractor intends to regain compliance with the schedule. Indicate changes to working hours, working days, crew sizes, and equipment required to achieve compliance, and date by which recovery will be accomplished.
 - 2. If, at any time, the critical path or major milestone Work is behind schedule with respect to the project progress schedule currently in force, and if the Engineer believes there is a risk of the Work not being completed within the Contract Time as a result of such delay, the Contractor shall take all necessary measures to make up for such delay either by increasing staff, plant or facilities, or by amending its Work methods, whichever is applicable.

- H. Computer Scheduling Software: Prepare schedules using Primavera P6 and provide in native software or Engineer approved equal scheduling software.
- 2.02 CONTRACTOR'S CONSTRUCTION SCHEDULE (CPM SCHEDULE):
- A. CPM Schedule: Prepare Contractor's construction schedule using a time-scaled CPM network analysis diagram for the Work.
 - 1. Develop network diagram in sufficient time to submit CPM schedule so it can be accepted for use no later than 60 days after date established for the Notice of Award.
 - a. Failure to include any work item required for performance of this Contract shall not excuse Contractor from completing all work within applicable completion dates, regardless of Engineer's acceptance of the schedule.
 - 2. Conduct educational workshops to train and inform key Project personnel, including subcontractors' personnel, in proper methods of providing data and using CPM schedule information.
 - 3. Establish procedures for monitoring and updating CPM schedule and for reporting progress. Coordinate procedures with progress meeting and payment request dates.
 - 4. Use "one workday" as the unit of time for individual activities. Indicate nonworking days and holidays incorporated into the schedule in order to coordinate with the Contract Time.
 - B. CPM Schedule Preparation: Prepare a list of all activities required to complete the Work. Using the startup network diagram, prepare a skeleton network to identify probable critical paths.
 - 1. Activities: Indicate the estimated time duration, sequence requirements, and relationship of each activity in relation to other activities. Include estimated time frames for the following activities:
 - a. Preparation and processing of submittals.
 - b. Mobilization and demobilization.
 - c. Purchase of materials.
 - d. Delivery.
 - e. Fabrication.
 - f. Utility interruptions.
 - g. Installation.

- h. Work by Owner that may affect or be affected by Contractor's activities.
 - i. Functional Completion Testing,
 - j. Startup and commissioning.
 - k. O&M Manual development.
 - l. Training.
 - m. Performance Testing
 - n. Punch list and final completion.
 - o. Activities occurring following final completion.
- 2. Critical Path Activities: Identify critical path activities, including those for interim completion dates. Scheduled start and completion dates shall be consistent with Contract milestone dates.
 - 3. Processing: Process data to produce output data on a computer-drawn, time-scaled network. Revise data, reorganize activity sequences, and reproduce as often as necessary to produce the CPM schedule within the limitations of the Contract Time.
 - 4. Format: Mark the critical path. Locate the critical path near center of network; locate paths with most float near the edges.
 - a. Subnetworks on separate sheets are permissible for activities clearly off the critical path.

C. Contract Modifications:

- 1. For each proposed contract modification and concurrent with its submission, prepare a time-impact analysis using a network fragment to demonstrate the effect of the proposed change on the overall project schedule. Logically connect approved Contract changes into the CPM schedule. Each change will be identified by number and description, and activities/milestones will be added to record the following:
 - a. Date the change was identified
 - b. Date the change was priced (if applicable)
 - c. Start and finish dates of the changed Work
- 2. Extensions of the Contract Times must be substantiated by a complete schedule demonstration showing the cause and effect of the relevant issue on the then-current critical path.

- D. Schedule Updating: The CPM Progress Schedule will show the projected completion date of the Work based on the progress information inserted into it, without changes to the schedule logic or the original duration of any activity. The Contractor shall use the retained logic option when executing schedule calculation. Concurrent with making revisions to schedule, prepare tabulated reports showing the following:

1. Identification of activities that have changed.
2. Changes in early and late start dates.
3. Changes in early and late finish dates.
4. Changes in activity durations in workdays.
5. Changes in the critical path.
6. Changes in total float or slack time.
7. Changes in the Contract Time.

2.03 CONTRACTOR'S LOOK-AHEAD SCHEDULES:

- A. The Contractor shall provide short interval, i.e., 2-week, "look ahead" schedules bi-weekly, identifying Work that has been performed during the past two weeks and activities that are planned for the next four weeks. The short interval schedule shall be consistent with the progress schedule currently in force.
- B. The Look-Ahead Schedules shall generally reflect the Work associated with the Detailed Progress Schedule. The activities in the Look-Ahead Schedules shall be identified by the same number coding as the Detailed Progress Schedule and revised as necessary.
- C. The final format of the look-ahead schedules will be determined by the Engineer and Owner.

2.04 REPORTS:

- A. Daily Construction Reports: Prepare a daily construction report recording the following information concerning events at Project site:
1. List of subcontractors at Project site.
 2. List of separate contractors at Project site.
 3. Approximate count of personnel at Project site.
 4. Equipment at Project site.
 5. Material deliveries.

6. High and low temperatures and general weather conditions, including presence of rain or snow.
7. Accidents.
8. Meetings and significant decisions.
9. Unusual events (see special reports).
10. Stoppages, delays, shortages, and losses.
11. Meter readings and similar recordings.
12. Emergency procedures.
13. Orders and requests of authorities having jurisdiction.
14. Change Orders received and implemented.
15. Work Change Directives received and implemented.
16. Services connected and disconnected.
17. Equipment or system tests and startups.
18. Partial completions and occupancies.
19. Substantial Completions authorized.

2.05 SPECIAL REPORTS:

- A. General: Submit special reports directly to Owner within two day(s) of an occurrence. Distribute copies of report to parties affected by the occurrence.
- B. Reporting Unusual Events: When an event of an unusual and significant nature occurs at Project site, whether or not related directly to the Work, prepare and submit a special report. List chain of events, persons participating, response by Contractor's personnel, evaluation of results or effects, and similar pertinent information. Advise Owner in advance when these events are known or predictable.

PART 3 - EXECUTION

3.01 CONTRACTOR'S CONSTRUCTION SCHEDULE:

- A. Contractor's Construction Schedule Updating: At monthly intervals, update schedule to reflect actual construction progress and activities. Issue schedule one week before each regularly scheduled progress meeting.

1. Revise schedule immediately after each meeting or other activity where revisions have been recognized or made. Issue updated schedule concurrently with the report of each such meeting.
2. Include a report with updated schedule that indicates every change, including, but not limited to, changes in logic, durations, actual starts and finishes, and activity durations.
3. As the Work progresses, indicate final completion percentage for each activity.

END OF SECTION

SECTION 01 32 33

CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide construction photographs pertinent to the Contract work during the Contract period as indicated and in compliance with Contract Documents.
 - 1. Section includes administrative and procedural requirements for the following:
 - a. Preconstruction photographs.
 - b. Periodic construction photographs.
 - c. Final completion construction photographs.
 - d. Preconstruction video recordings.
 - e. Periodic construction video recordings.

1.02 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
- B. Key Plan: Submit key plan of Project site and building with notation of vantage points marked for location and direction of each photograph and video recording. Indicate elevation or story of construction. Include same information as corresponding photographic documentation.
- C. Digital Photographs: Submit image files within three days of taking photographs.
 - 1. Submit video recordings by posting to Procore.
 - 2. Identification: Provide the following information with each image description in file metadata tag:
 - a. Name of Project
 - b. Name and contact information for photographer.
 - c. Name of Engineer
 - d. Name of Contractor.
 - e. Date photograph was taken.

- f. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
 - g. Unique sequential identifier keyed to accompanying key plan.
- D. Video Recordings: Submit video recordings within seven days of recording.
 - 1. Submit video recordings by posting to Project Web site.
 - 2. Identification: With each submittal, provide the following information:
 - a. Name of Project
 - b. Name and address of photographer.
 - c. Name of Engineer
 - d. Name of Contractor.
 - e. Date video recording was recorded.
 - f. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
 - g. Weather conditions at time of recording.

1.03 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Photographer to use techniques, material, and equipment capable of producing photographs of high quality and resolution.
 - 1. The records to be in sufficient detail to support any attestation that may be required of photographer.
 - 2. Photographer to retain such records for a period not less than two years from the final acceptance of entire work under this Contract.

1.04 USAGE RIGHTS:

- A. Obtain and transfer copyright usage rights from photographer to Owner for unlimited reproduction of photographic documentation.

1.05 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PHOTOGRAPHIC MEDIA:

- A. Digital Images: Provide high-resolution, digital photograph in format acceptable to Engineer.
- B. Digital Video Recordings: Provide high-resolution, digital video disc in format acceptable to Engineer.

PART 3 - EXECUTION

3.01 CONSTRUCTION PHOTOGRAPHS:

- A. General: Take photographs using the maximum range of depth of field, and that are in focus, to clearly show the Work. Photographs with blurry or out-of-focus areas will not be accepted.
- B. Digital Images: Submit digital images exactly as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software.
 - 1. Date and Time: Include date and time in file name for each image.
 - 2. Field Office Images: Maintain one set of images accessible in the field office at Project site, available at all times for reference. Identify images in the same manner as those submitted to Engineer.
- C. Preconstruction Photographs: Before commencement of excavation, take photographs of Project site and surrounding properties, including existing items to remain during construction, from different vantage points, as directed by Engineer.
 - 1. Flag excavation areas before taking construction photographs.
 - 2. Take sufficient photographs to document existing site conditions adjacent to property before starting the Work.
 - 3. Take minimum of 20 photographs of existing buildings either on or adjoining property to accurately record physical conditions at start of construction.
 - 4. Take additional photographs as required to record settlement or cracking of adjacent structures, pavements, and improvements.
- D. Periodic Construction Photographs: Take minimum of 20 photographs weekly, with timing each month adjusted to coincide with the cutoff date associated with each Application for Payment. Select vantage points to show status of construction and progress since last photographs were taken.

- E. Engineer-Directed Construction Photographs: From time to time, Engineer will instruct photographer about number and frequency of photographs and general directions on vantage points. Select actual vantage points and take photographs to show the status of construction and progress since last photographs were taken.
- F. Time-Lapse Sequence Construction Photographs: Take photographs at four fixed locations to show time-lapse sequence of construction and progress since last photographs were taken.
 - 1. Frequency: Take photographs weekly, with timing each month adjusted to coincide with the cutoff date associated with each Application for Payment.
 - 2. Vantage Points: Following suggestions by Engineer and Contractor, photographer to select vantage points. During each of the following construction phases, take one photographs from the four fixed locations to create a time-lapse sequence as follows:
 - a. Site upon completion of site clearing.
 - b. At completion of each structural excavation.
 - c. At completion of each structural foundation.
 - d. At completion of framing or forming for structures.
 - e. At completion of enclosures of structures.
 - f. At 1-month intervals, progress photography during construction of facilities. Photos of any month need show only new work performed during month.
 - g. Such special photographs required by Engineer.
 - h. Interior Work, through date of Substantial Completion.
 - 3. Views:
 - a. Coordinate with Engineer on views to be taken. In general views from locations to adequately illustrate state of project and condition of construction.
 - b. At least 3 different views of photographic subject except over-all site photography to have at least 4 different views unless otherwise approved by Engineer.
 - c. Succeeding photography of same photographic subject to be taken, insofar as practical, from the same view points as preceding photographic sessions. Variations in this procedure to be approved by Engineer.

G. Final Completion Construction Photographs: Take **20** color photographs after date of Substantial Completion for submission as project record documents. **Engineer** will inform photographer of desired vantage points.

1. Do not include date stamp.

H. Additional Photographs: Engineer may request photographs in addition to periodic photographs specified. Additional photographs will be paid for by Change Order and are not included in the Contract Sum.

1. Three days' notice will be given, where feasible.

2. In emergency situations, take additional photographs within 24 hours of request.

3. Circumstances that could require additional photographs include, but are not limited to, the following:

- a. Special events planned at Project site.

- b. Immediate follow-up when on-site events result in construction damage or losses.

- c. Photographs to be taken at fabrication locations away from Project site. These photographs are not subject to unit prices or unit-cost allowances.

- d. Substantial Completion of a major phase or component of the Work.

- e. Extra record photographs at time of final acceptance.

- f. Owner's request for special publicity photographs.

3.02 ROUTE PHOTOGRAPHY REQUIRED:

A. Provide progressive photographs of route before commencement of construction:

1. Progressive photographs of route starting at one end of route and progressing to other end then reverse progressive photography back to point of beginning.

2. Each exposure to overlap preceding exposure by 1/4 to 1/3 of the frame.

3. Additional photographs of features along route as directed by Engineer.

B. In the portions of the route where clearing is required make an additional set of progress photographs in similar manner specified for the initial route photography after all clearing work completed and before any other work commences in the cleared portion of the route.

C. During Construction:

1. At least once per week to illustrate state of project, condition of construction and progress in the previous week. Work photographed in previous sessions only photographed again sufficiently to provide progressive continuity of work unless otherwise directed by Engineer.
2. Such special photographs required by Engineer.

D. Upon Completion of All Construction Work:

1. Progressive photographs of route in same manner as that specified before commencement of Contract Work.
2. The route may be photographed in increments when work in that increment is completed and when approved by Engineer. Each increment photography to overlap other increment photography sufficiently such that all photographs provide progressive views of the route throughout.

3.03 CONSTRUCTION VIDEO RECORDINGS:

- A. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed, recent events, and planned activities. At each change in location, describe vantage point, location, direction (by compass point), and elevation or story of construction.
1. Confirm date and time at beginning and end of recording.
 2. Begin each video recording with name of Project, Contractor's name, videographer's name, and Project location.
- B. Preconstruction Video Recording: Before starting excavation, record video recording of Project site and surrounding properties from different vantage points.
1. Flag excavation areas before recording construction video recordings.
 2. Show existing conditions adjacent to Project site before starting the Work.
 3. Show existing buildings either on or adjoining Project site to accurately record physical conditions at the start of excavation.
 4. Show protection efforts by Contractor.
- C. Periodic Construction Video Recordings: Record video recording monthly, coinciding with the cutoff date associated with each Application for Payment. Select vantage points to show status of construction and progress since last video recordings were recorded.

END OF SECTION

SECTION 01 33 00

SUBMITTALS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This Section specifies the general methods and requirements of submissions applicable to the following work-related submittals as indicated and in compliance with Contract Documents.
 - 1. Shop Drawings, Product Data and Samples.
 - 2. Mock Ups.
 - 3. Construction Photographs.
 - 4. Contractor's Responsibilities.
 - 5. Submission Requirements.
 - 6. Review of Shop Drawings, Product Data, Working Drawings and Samples.
 - 7. Distribution.
 - 8. General Procedures for Submittals.
 - 9. Certificate of Design.
 - 10. Certificates of Compliance.
 - 11. Schedules.
- B. Detailed submittal requirements will be specified in the technical specifications section.

1.02 DEFINITIONS:

- A. Written and graphic information and physical samples that require Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."
- B. Portable Document Format (PDF): An open standard file format licensed by Adobe Systems used for representing documents in a device-independent and display resolution-independent fixed-layout document format.
- C. Shop drawings, as defined in the General Conditions, and as specified in individual work Sections include, but are not necessarily limited to: custom-prepared data such as

fabrication and erection/installation (working) drawings of concrete reinforcement, structural details and piping layout, scheduled information, setting diagrams, actual shopwork manufacturing instructions, custom templates, special wiring diagrams, coordination drawings, individual system or equipment inspection and test reports including performance curves and certifications as applicable to the work.

1.03 SUBMITTALS:

- A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and additional time for handling and reviewing submittals required by those corrections.
1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.
 2. Initial Submittal: Submit concurrently with startup construction schedule. Include submittals required during the first 60 days of construction. List those submittals required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.
 3. Final Submittal: Submit concurrently with the first complete submittal of Contractor's construction schedule.
 - a. Submit revised submittal schedule to reflect changes in current status and timing for submittals.
 4. Format: Arrange the following information in a tabular format:
 - a. Scheduled date for first submittal.
 - b. Specification Section number and title.
 - c. Submittal category: Action; informational.
 - d. Name of subcontractor.
 - e. Description of the Work covered.
 - f. Scheduled date for Engineer's final release or acceptance.
 - g. Scheduled date of fabrication.
 - h. Scheduled dates for purchasing.
 - i. Scheduled dates for installation.
 - j. Activity or event number.

1.04 SUBMITTAL ADMINISTRATIVE REQUIREMENTS:

- A. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
 - 1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
 - 2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on accepted submittal schedule.
 - 3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
 - 4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
 - a. Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
 - 5. The Contractor shall revise and resubmit rejected submittals and those requiring corrections or verification of information in a timely manner such that the overall progress of the Work is not impeded.
 - 6. Coordination of Submittal Times: The Contractor shall prepare and transmit each submittal sufficiently in advance of performing the related Work or other applicable activities, or within the time specified in the individual Sections of the Specifications, so that the installation will not be delayed by processing times, including rejection and resubmittal (if required), coordination with other submittals, testing, purchasing, fabrication, delivery, and similar sequenced activities. No extension of Contract Time will be authorized because of the Contractor's failure to transmit submittals sufficiently in advance of the Work.
- B. All shop drawings shall be submitted using the transmittal form approved by the Engineer.
- C. Submittals shall be managed through the Procore construction management system as specified in Section 01 31 24.
- D. All shop drawings submitted by subcontractors for approval shall be sent directly to the Contractor for checking. The Contractor shall be responsible for their submission at the proper time so as to prevent delays in delivery of materials.
- E. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Engineer's receipt of submittal. No

extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 15 working days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
 2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
 3. Resubmittal Review: Allow 15 working days for review of each resubmittal.
 4. Sequential Review: Where sequential review of submittals by Engineer's consultants, Owner, or other parties is indicated, allow 21 working days for initial review of each submittal.
- F. Physical Submittals: Where physical submittals are specified, place a permanent label or title block on each submittal item for identification.
1. Indicate name of firm or entity that prepared each submittal on label or title block.
 2. Include the following information for processing and recording action taken:
 - a. Project name.
 - b. Date.
 - c. Name of Engineer.
 - d. Name of Contractor.
 - e. Name of subcontractor.
 - f. Name of supplier.
 - g. Name of manufacturer.
 - h. Submittal number or other unique identifier, including revision identifier.
 - (1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 061000.01.A).
 - i. Number and title of appropriate Specification Section.
 - j. Drawing number and detail references, as appropriate.

- k. Location(s) where product is to be installed, as appropriate.
 - l. Other necessary identification.
 - 3. Transmittal: Assemble each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form. Engineer will discard submittals received from sources other than Contractor.
- G. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:
 - 1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
 - 2. Name file with submittal number or other unique identifier, including revision identifier.
 - a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A).
 - 3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Engineer.
 - 4. Provide electronic bookmarks with the electronic submittal.
 - 5. Provide a copy of the specification section with exceptions noted including an explanation.
 - 6. Transmittal Form for Electronic Submittals: Use software-generated form from electronic project management software or electronic form acceptable to Engineer, containing the following information:
 - a. Project name.
 - b. Date.
 - c. Name and address of Engineer.
 - d. Name of Contractor.
 - e. Name of firm or entity that prepared submittal.
 - f. Names of subcontractor, manufacturer, and supplier.
 - g. Category and type of submittal.

- h. Submittal purpose and description.
 - i. Specification Section number and title.
 - j. Specification paragraph number or drawing designation and generic name for each of multiple items.
 - k. Drawing number and detail references, as appropriate.
 - l. Location(s) where product is to be installed, as appropriate.
 - m. Related physical samples submitted directly.
 - n. Indication of full or partial submittal.
 - o. Transmittal number, numbered consecutively.
 - p. Submittal and transmittal distribution record.
 - q. Other necessary identification.
 - r. Remarks.
7. Metadata: Include the following information as keywords in the electronic submittal file metadata:
- a. Project name.
 - b. Number and title of appropriate Specification Section.
 - c. Manufacturer name.
 - d. Product name.
- H. Options: Identify options requiring selection by Engineer.
- I. Deviations and Additional Information: On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by Engineer on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.
- J. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.
- 1. Note date and content of previous submittal.
 - 2. Note date and content of revision in label or title block and clearly indicate extent of revision.

3. Resubmit submittals until they are marked with acceptance notation from Engineer's action stamp.
 - K. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.
 - L. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with acceptance notation from Engineer's action stamp.
- 1.05 CONSTRUCTION PHOTOGRAPHS:
- A. The Contractor shall provide construction photographs in accordance with requirements specified in Section 01 32 33.

PART 2 - PRODUCTS

2.01 SUBMITTAL PROCEDURES:

- A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
 1. Post electronic submittals as PDF electronic files directly to Procore construction management system.
 - a. Engineer will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.
 - b. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.
- B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.
 1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
 2. Mark each copy of each submittal to show which products and options are applicable.
 3. Include the following information, as applicable:
 - a. Manufacturer's catalog cuts.
 - b. Manufacturer's product specifications.

- c. Standard color charts.
 - d. Statement of compliance with specified referenced standards.
 - e. Testing by recognized testing agency.
 - f. Application of testing agency labels and seals.
 - g. Notation of coordination requirements.
 - h. Availability and delivery time information.
4. For equipment, include the following in addition to the above, as applicable:
- a. Wiring diagrams showing factory-installed wiring.
 - b. Printed performance curves.
 - c. Operational range diagrams.
 - d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.
5. Submit Product Data before or concurrent with Samples.
- C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.
1. Certified shop and erection drawings. Contractor shall submit electronic files of the proposed equipment in the capacity, size, and arrangement as indicated and specified. Electronic files shall conform to the following minimum requirements:
- a. Electronic Files: Revit or AutoCAD latest version, 3D, drawn to scale.
 - b. Submit electronic files as part of the Shop Drawing submittal.
 - c. Drawings shall include plan views, sectional views, title block, Tag Numbers, serial numbers, Parts List (identifying each component), dimensions, connection sizes and types and all details of all related items. In cases where certain information is proprietary and is omitted, provided a statement indicating that the information is proprietary and is being omitted.
 - d. Drawings shall be in conformance with all other requirements as specified in this specification.
2. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

- a. Identification of products.
 - b. Schedules.
 - c. Compliance with specified standards.
 - d. Notation of coordination requirements.
 - e. Notation of dimensions established by field measurement.
 - f. Relationship and attachment to adjoining construction clearly indicated.
 - g. Seal and signature of professional engineer if specified.
3. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets 22 by 34 inches.
 4. Submit Shop Drawings in electronic pdf file format:
- D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.
1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
 2. Identification: Attach label on unexposed side of Samples that includes the following:
 - a. Generic description of Sample.
 - b. Product name and name of manufacturer.
 - c. Sample source.
 - d. Number and title of applicable Specification Section.
 - e. Specification paragraph number and generic name of each item.
 3. For projects where electronic submittals are required, provide corresponding electronic submittal of Sample transmittal, digital image file illustrating Sample characteristics, and identification information for record.
 4. Disposition: Maintain sets of accepted Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

- a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.
 - b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.
- 5. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.
 - a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Engineer will return submittal with options selected.
- 6. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured, and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.
 - a. Number of Samples: Submit three sets of Samples. Engineer will retain two Sample sets; remainder will be returned. Mark up and retain one returned Sample set as a project record sample.
 - (1) Submit a single Sample where assembly details, workmanship, fabrication techniques, connections, operation, and other similar characteristics are to be demonstrated.
 - (2) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.
- E. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:
 - 1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
 - 2. Manufacturer and product name, and model number if applicable.
 - 3. Number and name of room or space.

4. Location within room or space.
5. Submit product schedule in PDF electronic file format:
 - a. PDF electronic file.
- F. Coordination Drawing Submittals: Comply with requirements specified in Section 01 33 00.
- G. Contractor's Construction Schedule: Comply with requirements specified in Section 01 32 17.
- H. Test and Inspection Reports and Schedule of Tests and Inspections Submittals: Comply with requirements specified in Division 01 Section "Quality Requirements."
- I. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Division 01 Section "Contract Closeout."
- J. Maintenance Data: Comply with requirements specified in Division 01 Section "Operation and Maintenance Data."
- K. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of Engineers and owners, and other information specified.
- L. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.
- M. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.
- N. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.
- O. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.
- P. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.
- Q. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

- R. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.
- S. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:
 - 1. Name of evaluation organization.
 - 2. Date of evaluation.
 - 3. Time period when report is in effect.
 - 4. Product and manufacturers' names.
 - 5. Description of product.
 - 6. Test procedures and results.
 - 7. Limitations of use.
- T. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.
- U. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.
- V. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.
- W. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.02 DELEGATED-DESIGN SERVICES:

- A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract

Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.
- B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
 1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.01 CONTRACTOR'S REVIEW:

- A. Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents prior to submission to the Engineer. Mark with approval stamp before submitting to Engineer.
- B. Contractor review shall verify the following:
 1. Field measurements
 2. Field construction criteria
 3. Catalog numbers and similar data
 4. Conformance with the Specifications
- C. If a shop drawing shows any deviation from the requirements of the Contract Documents, the Contractor shall make specific mention of the deviations in the Transmittal Form furnished by the Engineer and provide a description of the deviations in a letter attached to the submittal.
- D. The review and approval of shop drawings, samples or product data by the Engineer shall not relieve the Contractor from his responsibility with regard to the fulfillment of the terms of the Contract. All risks of error and omission are assumed by the Contractor and the Engineer will not have responsibility for any such errors and omissions.
- E. No portion of the work requiring a shop drawing, sample, or product data shall be started nor shall any materials be fabricated or installed prior to the approval or qualified approval of such item by the Engineer. Any fabrication performed, materials purchased or on-site construction accomplished which does not conform to accepted shop drawings

and data shall be at the Contractor's own risk. The Owner will not be liable for any expense or delay due to corrections or remedies required to accomplish conformity with the requirements of the Contract.

- F. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.02 ENGINEER'S ACTION:

- A. The Engineer's review is for general conformance with the design concept and contract documents. Markings or comments shall not be construed as relieving the Contractor from compliance with the contract plans and specifications or from departures therefrom. The Contractor remains responsible for details and accuracy, for coordinating the work with all other associated work and trades, for selecting fabrication processes, for techniques of assembly, and for performing work in a safe manner.
- B. Submittals will be reviewed for the Contractor's approval stamp. Submittals not stamped by the Contractor will be returned without any action.
- C. The review of shop drawings, data, and samples will be general. They shall not be construed:
 - 1. as permitting any departure from the Contract requirements;
 - 2. as relieving the Contractor of responsibility for any errors or omissions, including details, dimensions, and materials;
 - 3. as approving departures from details furnished by the Engineer, except as otherwise provided herein.
- D. If the shop drawings, data, or samples as submitted describe variations and show a departure from the Contract requirements which the Engineer finds to be in the interest of the Owner and to be so minor as not to involve a change in Contract Price or time for performance, the Engineer may return the reviewed drawings without noting an exception.
- E. Submittals will be returned to the Contractor under one of the action codes indicated below and defined on the transmittal form furnished by the Engineer.
 - 1. Marking: No Exception Taken.
 - a. When submittals are marked as "No Exception Taken," Work covered by submittal may proceed provided it complies with Contract Documents. Acceptance of Work depends on that compliance.
 - 2. Marking: Approved as Noted.

- a. When submittals are marked as “Approved as Noted,” Work covered by submittal may proceed provided it complies with Engineer’s notations or corrections on submittal and with Contract Documents. Acceptance of Work depends on that compliance. Resubmittal not required.
- 3. Marking: Revise and Resubmit.
 - a. When submittals are marked as “Revise and Resubmit,” do not proceed with Work covered by submittal. Do not permit Work covered by submittals to be used at Project site or elsewhere where Work is in progress.
 - b. Revise submittal or prepare new submittal in accordance with Engineer's notations in accordance with resubmittal requirements of this section. Resubmit without delay. Repeat if required to obtain different action marking.
- 4. Marking: Rejected; See Remarks.
 - a. When submittals are marked as “Rejected; See Remarks,” do not proceed with Work covered by submittal. Work covered by submittal does not comply with Contract Documents.
 - b. Prepare new submittal for different material or equipment supplier or different product line or material of same supplier complying with Contract Documents.
- 5. Marking: For Information Only.
 - a. When submittals are marked as “For Information Only,” the Engineer will review the submittal but take no action.
 - b. It will be recorded as “For Information Only”. Work covered by this submittal may proceed provided it complies with the Contract Documents.
- 6. Marking: Not Required for Review.
 - a. When submittals are marked as “Not Required for Review,” the Engineer has not reviewed the submittal and it is being returned.
 - b. Work covered by this submittal may proceed provided it complies with the Contract Documents.
- F. Resubmittals will be handled in the same manner as first submittals. On resubmittals the Contractor shall direct specific attention, in writing, on the letter of transmittal and on resubmitted shop drawings by use of revision triangles or other similar methods, to revisions other than the corrections requested by the Engineer, on previous submissions. Any such revisions which are not clearly identified shall be made at the risk of the Contractor. The Contractor shall make corrections to any Work done in relation to

revisions which are not specifically pointed out to the Engineer which are deemed, by the Engineer, not to be in accordance with the Contract Documents.

- G. Partial submittals may not be reviewed. The Engineer will be the only judge as to the completeness of a submittal. Submittals not complete will be returned to the Contractor and will be considered "Rejected" until resubmitted. The Engineer may at his option provide a list or mark the submittal directing the Contractor to the areas that are incomplete.
- H. If the Contractor considers any correction indicated on the shop drawings to constitute a change to the Contract Documents, the Contractor shall give written notice thereof to the Engineer at least seven working days prior to release for manufacture. The shop drawing and the Product data sheet reviews do not authorize changes in Contract Price or Contract Time. Changes involving Contract Price or Contract Time are authorized only by a signed Change Order, in accordance with the General Conditions.
- I. When the shop drawings have been completed to the satisfaction of the Engineer, the Contractor shall carry out the construction in accordance therewith and shall make no further changes therein except upon written instructions from the Engineer.
- J. Material and equipment delivered to the Site will not be paid for until the pertinent shop drawings have been reviewed and accepted by the Engineer.

3.03 DISTRIBUTION:

- A. Distribute reproductions of accepted shop drawings and copies of accepted product data and samples, where required, to the job site file and elsewhere as directed by the Engineer. Number of copies shall be as directed by the Engineer but shall not exceed 6.

3.04 CERTIFICATE OF DESIGN:

- A. If specifically specified in other Sections of these Specifications, the Contractor shall submit the applicable Certificate of Design for each item required, Form 01 33 00-1, completely filled in and signed and sealed by a registered professional engineer.

3.05 CERTIFICATES OF COMPLIANCE:

- A. Certificates of Compliance as specified in the specifications shall include and mean certificates, manufacturer's certificates, certifications, certified copies, letters of certification and certificate of materials.
- B. The Contractor shall be responsible for providing Certificates of Compliance as specified in the technical specifications. Certificates are required for demonstrating proof of compliance with specification requirements and shall be provided electronically and with one (1) print copy unless otherwise specified. Each certificate shall be signed by an official authorized to certify on behalf of the manufacturing company and shall contain the name and address of the Supplier, the project name and location, and the quantity and date or dates of shipment or delivery to which the certificates apply. Copies of

laboratory test reports submitted with certificates shall contain the name and address of the testing laboratory and the date or dates of the tests to which the report applies. Certification shall not be construed as relieving the Supplier from furnishing satisfactory material, if after tests are performed on selected samples, the material is found not to meet the specific requirements.

END OF SECTION

Form 01 33 00-1
CERTIFICATE OF DELEGATED DESIGN SERVICES

The undersigned hereby certifies that he/she is a Professional Engineer registered in the state of _____ and that he/she has been employed by (Name of Contractor) _____ to design _____ in accordance with Specifications Section _____ for the (Name of Project) _____. The undersigned further certifies that he/she has performed similar designs previously and has performed the design of the _____; that said design is in conformance with all applicable local, state, and federal codes, rules, and regulations and professional practice standards; that his/her signature and Professional Engineer (P.E.) Stamp have been affixed to all calculations and drawings used in, and resulting from, the design; and that the use of that stamp signifies the responsibility of the undersigned for that design.

The undersigned hereby certifies that he/she has Professional Liability Insurance with limits of \$1,000,000.00 and a Certificate of Insurance is attached.

The undersigned hereby agrees to make all original design drawings and calculations available to the Town/City of _____ or Owner's representative within seven (7) days following written request therefore by the Owner.

P.E. Name

Contractor's Name

Signature

Signature

Title

Title

Address

Address

Submittals
Section No. 01 33 00-18

SECTION 01 35 43

PROTECTION OF ENVIRONMENT

PART 1 - GENERAL

1.01 SUMMARY:

- A. Contractor, in executing Work, shall maintain Work areas on- and off-site free from environmental pollution that would be in violation of federal, state, or local regulations as indicated and in compliance with Contract Documents.
- B. The control of environmental pollution requires consideration of air, water, and land, and involves management of noise and solid waste, as well as other pollutants.
- C. Any contamination shall be reported by the Contractor to the Owner, the State and Local Authorities and cleaned up as required by the governing agency.
- D. The Contractor shall be responsible for the protection of the natural environment of the Site and surrounding areas, both land and water. Protection of the environment must start with avoidance and prevention, and then control/mitigation, compensation, or enhancement (in order of descending preference).
- E. Schedule and conduct all work in a manner that will minimize the erosion of soils in the area of the work. Provide erosion control measures such as diversion channels, sedimentation or filtration systems, berms, staked hay bales, seeding, mulching, or other special surface treatments as are required to prevent silting and muddying of streams, rivers, impoundments, lakes, etc. All erosion control measures shall be in place in an area prior to any construction activity in that area.
- F. Ensure that construction is achieved with a minimum of disturbance to the existing ecological balance between a water resource and its surroundings. It is the Contractor's responsibility to determine the specific construction techniques to meet these guidelines.
- G. Schedule and conduct all work in a manner that will minimize the level of noise escaping the site, especially at night and on weekends.
- H. Submit Storm Water Pollution Prevention Plan (SWPPP) in accordance with Section 01 33 00.
- I. Payment:
 - 1. Consider Work specified in this section incidental and include payment as part of appropriate lump sum or unit prices specified in Bid Form.

1.02 REFERENCES:

- A. United States Environmental Protection Agency (USEPA):

Protection of Environment
Section No. 01 35 43-1

1. EPA-72-015: Guidelines for Erosion and Sedimentation Control Planning and Implementation
2. EPA 43019-73-007: Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity

- B. Federal Environmental Protection Act and applicable regulations.
- C. Owner's environmental management plans and associated environmental protection plans.

1.03 ENVIRONMENTAL INSPECTION AND MONITORING

- A. The Contractor shall be responsible for conducting on-going environmental inspection and monitoring to ensure compliance with the required mitigation measures set out in the Environmental Protection Plans. This shall include identification of the appropriate remedial actions where required and implementation in a timely fashion.
- B. The Contractor is advised that inspectors from local authorities may make periodic visits to the site during construction. They have the power to order the Contractor to stop Work if the work, in their opinion is not being done to ensure compliance with environmental objectives. The Engineer's acceptance of the work may be withheld until the authorities concerned have issued their approval.

1.04 SUBMITTALS

- A. Submit shop drawings in accordance with the requirements of Section 01 33 00 "Submittals".
- B. Prior to commencing any Work on this Contract and not later than fifteen (15) Working Days following receipt of the Notice to Proceed, the Contractor shall submit Environmental Protection Plan for the Engineer's review and approval. Submit the following:
 1. Plans and sketches showing areas proposed to be used for construction storage, the Contractor's Site office, vehicle cleaning, equipment fueling, and associated access routes.
 2. Surface drainage and storm sewer control plan.
 3. Erosion and sediment control plan
 4. Waterways control plan.
 5. Tree protection plan.
 6. Air pollution control plan.
 7. Mud and dust control plan.

8. Noise control plan.
9. Fuels and lubricants storage and dispensing control plan.
10. Construction Equipment Cleaning control plan.
11. Spills response and spills reporting plan.
12. Erosion and sediment control contingency plan.
13. Fire contingency plan.
14. Contaminated site contingency plan.
15. Historical resources contingency plan.
16. Fuel spills contingency plan

1.05 PROTECTION OF STORM SEWERS:

- A. Prevent construction material (including volatile liquid wastes such as oil, chemicals, paints), pavement, concrete, earth, or other debris from entering existing storm sewer or sewer structure.

1.06 PROTECTION OF WATERWAYS:

- A. The Contractor shall not cause or permit action to occur which would cause an overflow to existing waterways. Provide holding ponds or accepted method which will divert flows, including storm flows and flows created by construction activity, to prevent excessive silting of waterways or flooding damage to property.
- B. Comply with procedures outlined in U.S. EPA manuals entitled, "Guidelines for Erosion and Sedimentation Control Planning and Implementation", Manual EPA-72-015 and "Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity", Manual EPA 43019-73-007

1.07 PROTECTION OF TREES:

- A. Only cut down trees shown on the Contract Drawings. Coordinate with the Owner and Engineer for approval prior to removing other trees.
- B. The Contractor shall take precautions to prevent damage to existing trees and shrubs, protect branches and foliage, protect trunks and stems, and prevent machinery from travelling over roots within the 'drip-line' of the trees by placing and maintaining snow fencing around each tree outside of the 'drip-line'. The Contractor shall not pile excavated material within the dripline of existing trees.
- C. Where damage does occur, it must be reported by the Contractor to the Engineer and repaired or replaced by a qualified person as directed by the Engineer. In the event of

damage to bark, trunks, limbs, or roots of plants that are not designated for removal, the Contractor shall treat damage by corrective pruning, bark tracing, application of a heavy coating of tree paint, and other accepted horticultural and tree surgery practices.

1.08 DISPOSAL OF EXCESS EXCAVATED AND OTHER WASTE MATERIALS:

- A. Excess excavated material not required or not suitable for backfill and other waste material shall be disposed of in accordance with local regulatory requirements.
- B. Provide watertight conveyance for liquid, semi-liquid or saturated solids which tend to bleed during transport. Liquid loss from transported materials is not permitted, whether being delivered to construction site or hauled away for disposal. Fluid materials hauled for disposal must be specifically acceptable at selected disposal site.

1.09 PROTECTION OF AIR QUALITY:

- A. Minimize air pollution by requiring use of properly operating combustion emission control devices on construction vehicles and equipment and encourage shutdown of motorized equipment not in use.
- B. Do not burn trash on or adjacent to construction site.
- C. If temporary heating devices are necessary for protection of Work, they shall not cause air pollution.
- D. The Contractor shall conduct operations of dumping rock and of carrying rock away in trucks in such a way as to minimize dust. Give unpaved streets, roads, detours, or haul roads used in construction area a dust-preventive treatment or periodically water them to prevent dust. Strictly adhere to all applicable environmental regulations for dust prevention.

1.10 THAWING OF FROZEN GROUND:

- A. Obtain permit from appropriate local authority, if required, before using any heating devices to thaw frozen ground and comply with conditions of permit.
- B. Use fuel which does not create air pollution or inconvenience public.
- C. Open wood fires are prohibited for thawing frozen ground.

1.11 USE OF CHEMICALS:

- A. Chemicals used during project construction or furnished for project operation, whether herbicide, pesticide, disinfectant, polymer, reactant or of other classification, shall be approved by U.S. EPA and any other applicable regulatory agency.
- B. Use and disposal of chemicals and residues shall comply with manufacturer's instructions.

1.12 NOISE CONTROL:

- A. Conduct operations to cause least annoyance to residents in vicinity of Work and comply with applicable local ordinances.
- B. Equip compressors, hoists, and other apparatus with mechanical devices necessary to minimize noise and dust. Equip compressors with silencers on intake lines.
- C. Equip gasoline or oil-operated equipment with silencers or mufflers on intake and exhaust lines.
- D. Line storage bins and hoppers with material that will deaden sounds.
- E. Conduct operation of dumping rock and of carrying rock away in trucks so as to cause minimum of noise and dust.
- F. Route vehicles carrying rock, concrete or other material over such streets as will cause least annoyance to public and do not operate on public streets between hours of 6:00 p.m. and 7:00 a.m., or on Saturdays, Sundays or legal holidays unless approved by Owner.
- G. No excessive idling of motorized equipment is permitted.
- H. Where necessary, the Contractor shall place noise attenuation devices (barriers) around the Contractor's construction equipment.
- I. Submit a plan to mitigate construction noise and to comply with noise control ordinances, including methods of construction, equipment to be used, and acoustical treatments.

1.13 MUD AND DUST CONTROL:

- A. Due to close geographic location of Project to other off-site facilities and residential buildings take special care in providing and maintaining temporary site roadways, Owner's existing roads, and public roads used during construction operations in clean, dust free condition.
- B. Comply with local environmental regulations for dust control. If Contractor's dust control measures are considered inadequate by Engineer, Engineer may require Contractor to take additional dust control measures.
- C. The Contractor shall provide and maintain temporary dust-tight partitions, bulkheads, or other protective devices during construction to permit normal operation of existing facilities. The Contractor shall construct partitions of plywood, insulating board, plastic sheets, or similar material. The Contractor shall construct partitions in such a manner that dust and dirt from demolition and cutting will not enter other parts of existing buildings or facilities. The Contractor shall remove temporary partitions as soon as the need for them no longer exists.

- D. The Contractor shall employ only wet type equipment for saw cutting and concrete grinding to control dust nuisance. There shall be no cutting prior to the Engineer's and Owner's approval.
- E. The Contractor shall obtain the Engineer's acceptance before chemicals for dust control are used. Sodium chloride is not permitted for dust control.
- F. All trenches and disturbed areas created during the execution of the Work that will produce dust shall be maintained dust free by an application of calcium chloride at the Engineer's direction.
- G. The Contractor shall not use calcium chloride on access roads.
- H. The Contractor shall transport dusty materials in covered haulage vehicles.
- I. The Contractor shall be responsible for a prompt and complete cleanup of all dirt and mud deposited on the public and/or private property as a consequence of the execution of the Work. If the Contractor fails to comply with this obligation the Owner may proceed with the necessary clean up and charge all the costs for the cleanup to the Contractor.
- J. The Contractor shall wash mud from construction vehicles before leaving the construction Site.
- K. The Contractor shall wash and clean the following roads at the end of each workday during the Contract:
 - 1. Major traffic routes inside the plant and City streets impacted by construction activities.
 - 2. Contractor shall provide vehicle tracking control pads at each exit location.

1.14 CLEANING OF EQUIPMENT

- A. The Contractor shall keep construction equipment clean so that no debris is deposited on the plant roadways or any public roadway. The Contractor shall identify a designated vehicle cleaning area within the working limits of the Contract. The Contractor shall contain all construction debris in this designated area only. The Contractor shall dispose of debris off Site.
- B. The Contractor shall ensure that debris cleaned from equipment cannot gain access to storm sewers and watercourses.

1.15 FUELS AND LUBRICANTS:

- A. Comply with local, state, and federal regulations concerning transportation and storage of fuels and lubricants.

- B. The Contractor shall designate an area within the working limits to be used exclusively for fueling of construction equipment. The Contractor shall carry out all refueling in this area only. Refueling of backhoes or shovels will be allowed at locations other than the accepted refueling areas, but not closer than 30 feet from any watercourse.
- C. Fuel storage area and fuel equipment shall be approved by Owner prior to installation. Submit containment provisions to Engineer for approval.
- D. The Contractor shall submit to the Engineer for review prior to starting the Work, procedures for the interception and rapid clean-up and disposal of fuel spillages which may occur. The Contractor shall ensure that the materials required for the clean-up of fuel spillages are always readily accessible on Site.
- E. The emptying of fuel, lubricants and pesticides into watercourses is prohibited. The Contractor shall contain fuel, lubricants, pesticides, and construction debris and dispose of it off Site in approved locations.
- F. Report spills or leaks from fueling equipment or construction equipment to Owner and cleanup as required by local, state, or federal regulations.
- G. Owner may require Contractor to remove damaged or leaking equipment from Project site.

1.16 PILE AND SHEATHING DRIVING NOISE:

- A. If piles are required, use only pile driver hammers with mufflers capable of significantly reducing noise and use barriers or shielding techniques to comply with applicable federal, state, and local ordinances.

1.17 CONTINGENCY AND EMERGENCY RESPONSE PLANS:

A. General

1. The Contractor shall adopt a pollution preventative strategy to fulfill its commitment to protecting public and worker health and safety, and the environment, as stipulated in the General Conditions under Occupational Health and Safety Act, and Environmental Protection Act. Through this strategy, the potential issues and emergency events that can be anticipated shall be identified by the Contractor and procedures put in place by the Contractor to minimize their potential occurrence.
2. To address any unanticipated events, the Contractor shall develop Contingency and Emergency Response Plans and implement these plans during the performance of the Work.

B. Spills Response and Spills Reporting:

1. Prior to commencing construction, the Contractor shall be responsible for preparing a Spills Response Plan. The Spills Response Plan must address the response, containment, and cleanup of an accidental spill. It must take care of the specific roles and responsibilities of construction staff, accountability, reporting and documentation. Specifically, the plan must include:
 - a. the names and the telephone numbers of the persons in the local municipalities to be notified forthwith of a spill
 - b. the names and the telephone numbers of the representatives of the fire, the police and the health departments of the local municipalities who are responsible to respond to emergency situations
 - c. the names and the telephone numbers of the companies experienced in the control and clean-up of hazardous materials that would be called upon in an emergency involving a spill
 - d. the Contractor's proposal for the immediate containment and control of the spill, the clean-up procedures to be initiated immediately and any other action to be taken to mitigate the potential environmental damage while awaiting additional assistance, and,
 - e. the name and the telephone number of the Contractor's representative responsible for preparing, implementing, directing, and supervising the contingency plan
2. The Contractor shall submit for the Engineer's review and for the review of other authorities having jurisdiction a copy of the Spills Response plan and shall make the appropriate changes to it based upon the comments received from these authorities
3. In the event of a spill or other emission of a pollutant caused by the execution of the Work into the natural environment, the Contractor shall immediately notify the Owner and Engineer of the spill, of the circumstances thereof, and of the action taken or intended to be taken with respect thereto:
4. The Contractor shall make the necessary allowances to ensure the immediate availability of the products with which to effect temporary repair to broken pipelines and other services, so the spill or other emission of a pollutant is immediately controlled and stopped and to mitigate the damages. The Contractor shall do everything practicable to restore the natural environment.
5. The Contractor shall prepare a written report of the spill, and the spill event is to be recorded in the Contractor's logbook. The report must contain the following information, at a minimum:
 - a. Date and time spill occurred.

- b. Estimated volume of spill.
- c. Duration of the spill.
- d. Cause and discovery of the spill.
- e. Cleanup and recovery measures taken.
- f. Name of hauler or outside contractors called in to assist with cleanup and recovery measures.
- g. Personnel on the scene.
- h. Names of parties and agencies notified and the date and time of notification of each.
- i. Steps to be taken to prevent a reoccurrence of the spill.

C. Fire Contingency Plan

- 1. The Contractor shall develop and submit a Fire Contingency Plan to ensure a rapid response to a fire thereby minimizing the threat to worker and public safety, and the environment.
- 2. The plan must include, but is not limited to, an explanation of the purpose of the plan and when the plan is triggered, an explanation of relevant roles and responsibilities, and accountability for implementing the plan, and provision of fire prevention training and equipment for implementing the plan.

1.18 NOTIFICATIONS:

- A. The Engineer will notify the Contractor in writing of any non-compliance with the foregoing provisions or of any environmentally objectionable acts and corrective action to be taken. State or local agencies responsible for verification of certain aspects of the environmental protection requirements shall notify the Contractor in writing, through the Engineer, of any non-compliance with State or local requirements. The Contractor shall, after receipt of such notice from the Engineer or from the regulatory agency through the Engineer, immediately take corrective action. Such notice, when delivered to the Contractor or his authorized representative at the site of the work, shall be deemed sufficient for the purpose. If the Contractor fails or refuses to comply promptly, the Owner may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to any such stop orders shall be made the subject of a claim for extension of time or for excess costs or damages by the Contractor unless it is later determined that the Contractor was in compliance. Failure of Owner, Engineer, or regulatory agency to provide notice of non-compliance to the Contractor does not relieve the Contractor from duty of compliance with all applicable rules and regulations.

1.19 WILDLIFE MITIGATION

- A. No nesting vegetation clearance (which can include trees, shrubs, and herbaceous vegetation such as grasses and forbs) can occur during the typical nesting/brood rearing season period from April 1 through August 30 or perform a nest clearance prior to starting work.
 - 1. Nest Clearance: Assign a qualified wildlife biologist to perform a nest clearance survey immediately prior (within 3 days) of construction activities if any vegetation clearing is required during the nesting/brood rearing period.
- B. If actively nesting and/or brood rearing birds are found within or reasonably near (200 feet or less) the vegetation clearance area, clearance and construction should be postponed until breeding activity is completed (as assessed by a qualified wildlife biologist).

1.20 CULTURAL RESOURCES

- A. CONTRACTOR's attention is directed to the National Historic Preservation Act of 1966 (16 U.S.C. 470) and 36 CFR 800 which provides for the preservation of potential historical architectural, archeological, or cultural resources (hereinafter called "cultural resources").
- B. CONTRACTOR shall conform to the applicable requirements of the National Historic Preservation Act of 1966 as it relates to the preservation of cultural resources.
- C. If a suspected or unsuspected historical, archaeological, or paleontological item, feature, or site or other cultural resource is encountered during subsurface excavations at the site of construction, the following procedures shall be instituted:
 - 1. Construction operations shall be immediately stopped in the vicinity of the discovery and Engineer and Owner shall be notified of the nature and exact location of the finding. Contractor shall not damage the discovered objects and shall provide written confirmation of the discovery to Engineer within two (2) calendar days.
 - 2. Owner and Engineer will then immediately notify the State Historical Preservation Office (SHPO) and the Utah Geological Survey (UGS).
 - 3. SHPO and UGS will investigate the finding and determine if the resource requires protection and the disposition of the said resource.
- D. If SHPO and UGS determine that the potential find is a bona fide cultural resource, CONTRACTOR shall suspend work at the location of the find under the provisions for changes contained in Articles 11, 12, and 13 of the General Conditions, Section 00 70 00 – General Conditions.

1.21 IMPLEMENTATION:

- A. Prior to commencement of the work, meet with the Engineer to develop mutual understandings relative to compliance with this provision and administration of the environmental pollution control program.
- B. Remove temporary environmental control features, when accepted by the Engineer, and incorporate permanent control features into the project at the earliest practicable time.
- C. Implementation of the Contingency and Emergency Response Plans
 - 1. The responsibility for implementing the Contingency and Emergency Response Plans shall lie with the Contractor. Specific responsibilities include:
 - a. Reviewing the Contingency Plans and Emergency Response Plans and identifying any issues / concerns and providing suggested changes / updates;
 - b. Ensuring that all construction staff are trained in Contingency Plan Implementation and Emergency Response Techniques and that they have the appropriate equipment on hand;
 - c. Providing advice to construction staff on proper emergency response procedures;
 - d. Auditing the Contractor's response to events resulting in the activation of its Contingency Plans and Emergency Response Plans;
 - e. Initiating actions to correct any response deficiencies identified through the audit process and reporting it;
 - f. Maintaining emergency response records for review by the Engineer and the appropriate regulatory agencies.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01 41 20
SEISMIC AND WIND REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section establishes the minimum seismic design requirements for architectural, mechanical, electrical and non-structural components.
- B. The Contractor shall be responsible for the seismic requirements specified including the conformance of work for all subcontractors, manufacturers and suppliers with regard to the indicated and specified seismic requirements.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 318: Building Code Requirements for Structural Concrete
- B. American Petroleum Institute (API):
 - 1. STD 650: Welded Steel Tanks for Oil Storage
- C. American Society of Civil Engineers (ASCE):
 - 1. 7-16: Minimum Design Loads for Buildings and Other
- D. American Society of Mechanical Engineers (ASME):
 - 1. A17.1: Safety Code for Elevators and Escalators
 - 2. B31: Code for Pressure Piping
 - 3. Boiler and Pressure Vessel Code
- E. ASTM International (ASTM):
 - 1. C635: Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems or Acoustical Tile and Lay-in Panel Ceilings
 - 2. C636: Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels

- F. American Water Works Association (AWWA):
 - 1. D100: Welded Steel Tanks for Water Storage
 - 2. D110: Wire Wound Prestressed Concrete Tanks for Water Storage
 - G. FEMA NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, 2015 Edition
 - H. International Code Council (ICC):
 - 1. International Building Code 2018
 - I. Manufacturers Standardization Society of the Valve and Fitting Industry:
 - 1. SP-58: Pipe Hangers and Supports - Materials, Design and Manufacture
 - J. National Fire Protection Association (NFPA):
 - 1. Standard for the Installation of Sprinkler Systems
 - K. Rack Manufacturers Institute:
 - 1. Specification for the Design, Testing, and Utilization of Industrial Steel Storage Racks
- 1.03 DEFINITIONS:
- A. Components are defined as systems, equipment, parts, or other elements, including supporting structures and attachments.
 - B. The reference building code is defined as the building code cited on the structural drawings or specified herein for the design of the basic structure.
 - C. The specified seismic criteria is defined as the seismic criteria cited on the structural drawings or specified herein for the design of the basic structure.
 - D. The specified wind criteria is defined as the wind criteria cited on the structural drawings or specified herein for the design of the basic structure.
- 1.04 MINIMUM DESIGN REQUIREMENTS:
- A. Architectural, mechanical, electrical and non-structural components shall be designed and constructed to resist the seismic and wind forces and displacements based upon ASCE/SEI 7, the reference building code, and the specified seismic and wind criteria. In the case of conflict the more stringent requirements shall govern.

- B. The interrelationship of components and their effect on each other shall be such that the failure of one component shall not cause the failure of any other component.
- C. Components shall be anchored to the building structure to transfer seismic and wind forces. Connections shall be bolted, welded or otherwise positively anchored to the structure. Anchorage shall not rely on friction for force transfer.
- D. Exceptions: Exemption from the requirements for seismic and wind analysis and design are permitted only to the extent permitted in the reference code.
- E. The following design criteria shall be used in conjunction with the appropriate minimum design criteria section listed below.
 - 1. Structures or systems related to WTP operation:
 - a. Occupancy Category: IV
- F. Seismic bracing for Fire protection piping shall be designed in accordance with FM Global requirements.

1.05 WIND LOADING MINIMUM DESIGN CRITERIA:

- A. Design in accordance with the requirements of the above referenced codes.
 - 1. Wind Speed : 115 miles per hour for Risk Category IV structures
 - 2. Wind Exposure: C

1.06 SEISMIC LOADING MINIMUM DESIGN CRITERIA:

- A. Design Requirements: Design in accordance with the requirements of the above referenced codes.
 - 1. Risk Category:
 - a. IV
 - 2. Short Period MCE (S_s) = 1.38
 - 3. Long Period MCE (S_1) = 0.51
 - 4. Soil Site Class: D
 - 5. Seismic Parameters for Soil Site Class D:
 - a. Site Coefficient, F_a = 1.0
 - b. Site Coefficient, F_v = 1.79

- c. Site Specific Short Period Spectral Acceleration (SDS) = 0.92
- d. Site Specific Long Period (1-sec) Spectral Acceleration (SD1) = 0.61
- 6. Seismic Design Category: D
- 7. Importance Factor (Ie):
 - a. Select based upon Risk Category and corresponding values provided by ASCE/SEI 7.
- 8. Component Importance Factor (Ip):
 - a. Equipment and systems related to operations, including but not limited to pumping systems, supply piping; $I_p = 1.5$
 - b. Other structures, $I_p = 1.0$
- 9. Seismic response coefficient (Cs): is determined by ASCE/SEI 7 Equation 12.8-2 for values of $T \leq 1.5T_s$ and taken as equal to 1.5 times the value computed in accordance with either Equation 12.8-3 for $T_L \geq T > 1.5T_s$ or Equation 12.8-4 for $T > T_L$.
- 10. Selection and application of the appropriate seismic design sections of ASCE/SEI 7 shall be the responsibility of the Engineer responsible for the element being designed; however, final approval of the selected section of ASCE 7 shall be provided by the Engineer.

1.07 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Where specified in the technical specifications, provide and complete the Certificate of Unit Responsibility form in Section 01 33 00 and submit to Engineer prior to manufacture of components.
- C. In addition, submit the following support data along with Certificate of Unit Responsibility:
 - 1. Certification, signed and sealed by a Professional Structural Engineer registered in the jurisdiction where the project is located, stating that all systems, equipment, and other elements, including supporting structures, attachments and connections are designed to withstand the required seismic and wind forces and displacements.
 - 2. Codes and specifications to which structural design conforms.
- D. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.

- E. Manufacturer's information and catalog data showing compliance with this specification and a full description of the product.
- F. Design calculations for shoring systems and support and anchorage of equipment and appurtenances. Calculations shall be stamped and signed by a civil or structural engineer currently licensed in the State of Utah and submitted under the appropriate technical specification Section.
- G. Submit complete shop drawings and corresponding calculations that thoroughly cover the work elements associated with an area of work being requested for review.
 - 1. Calculations shall be signed and stamped by a civil or structural engineer licensed in the State of Utah and submitted under the appropriate technical specification section.

1.08 SPECIFIC COMPONENTS:

- A. Compound Equipment: Connecting elements for equipment combinations such as pumps and motors, valves and operators, engines and generators, etc. which are not capable of transferring seismic and/or wind loads or accommodating seismic and wind displacements shall be protected by appropriate design.
- B. Storage Tanks: Tanks, supporting structures and anchorages shall be designed for the weight of the tank, appurtenances and the tank contents at the maximum capacity. Tank contents shall not be considered in resistance to seismic and wind loads.
 - 1. Where applicable include impulsive and convective "sloshing" effects.
 - 2. Component response modification factor for impulsive effects, R_i : In accordance with ASCE 7, Table 15.4-2.
 - 3. Component response modification factor for convective effects, $R_c = 1.0$.
 - 4. Component importance factor, I_e : Determine in accordance with ASCE 7, Section 15.4.1.1.
- C. Ductwork: Equipment installed within ductwork shall be independently supported and braced. Support and bracing of heating and cooling coils shall account for the weight of the contents.
- D. Piping Systems: Support and bracing of piping systems shall account for the weight and hydrodynamic effects of the contents.
- E. Pressure Piping: Pressure piping support and bracing shall conform to ASME B31 in addition to the force and displacement requirements of the reference code.

- F. Sprinkler Systems: Sprinkler system support and bracing shall conform to NFPA 13 in addition to the force and displacement requirements of the reference code.
- G. General Supports: Pipe, duct, raceways and cable tray supports and bracing shall conform to the AISC Manual of Steel Construction and MSS SP-58 in addition to the force and displacement requirements of the reference code.
- H. Submerged components shall be designed for hydrodynamic sloshing forces.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 01 43 00

QUALITY REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section covers Quality Assurance and Quality Control requirements for this contract as indicated and in compliance with Contract Documents.
- B. The Contractor is responsible for controlling the quality of work, including work of its subcontractors, and suppliers and for assuring the quality specified in the Technical Specifications is achieved.

1.02 SUMMARY:

- A. Section includes administrative and procedural requirements for quality assurance and quality control.
- B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
 - 1. Specific quality-assurance and quality-control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
 - 2. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and quality-control procedures that facilitate compliance with the Contract Document requirements.
 - 3. Requirements for Contractor to provide quality-assurance and quality-control services required by Engineer, Owner, or authorities having jurisdiction are not limited by provisions of this Section.
- C. Related Requirements:
 - 1. Divisions 02 through 46 Sections for specific test and inspection requirements.

1.03 DEFINITIONS:

- A. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
- B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work

and completed construction comply with requirements. Services do not include contract enforcement activities performed by Engineer.

- C. Mockups: Full-size physical assemblies that are constructed on-site. Mockups are constructed to verify selections made under Sample submittals; to demonstrate aesthetic effects and, where indicated, qualities of materials and execution; to review coordination, testing, or operation; to show interface between dissimilar materials; and to demonstrate compliance with specified installation tolerances. Mockups are not Samples. Unless otherwise indicated, accepted mockups establish the standard by which the Work will be judged.
 - 1. Integrated Exterior Mockups: Mockups of the exterior envelope erected separately from the building but on Project site, consisting of multiple products, assemblies, and subassemblies.
- D. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria.
- E. Product Testing: Tests and inspections that are performed by a Nationally Recognized Testing Laboratory (NRTL), an (National Voluntary Laboratory Accreditation Program (NVLAP), or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.
 - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- F. Source Quality-Control Testing: Tests and inspections that are performed at the source, e.g., plant, mill, factory, or shop.
- G. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- H. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- I. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.
 - 1. Use of trade-specific terminology in referring to a trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).

- J. Experienced: When used with an entity or individual, "experienced" means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.04 CONFLICTING REQUIREMENTS:

- A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Engineer for a decision before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Engineer for a decision before proceeding.

1.05 SUBMITTALS:

- A. Shop Drawings: For integrated exterior mockups, provide plans, sections, and elevations, indicating materials and size of mockup construction.
 - 1. Indicate manufacturer and model number of individual components.
 - 2. Provide axonometric drawings for conditions difficult to illustrate in two dimensions.
- B. Contractor's Quality-Control Plan: For quality-assurance and quality-control activities and responsibilities.
- C. Qualification Data: For Contractor's quality-control personnel.
- D. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility sent to authorities having jurisdiction before starting work on the following systems:
 - 1. Seismic-force-resisting system, designated seismic system, or component listed in the designated seismic system quality-assurance plan prepared by a state licensed Engineer approved by Owner.
 - 2. Main wind-force-resisting system or a wind-resisting component listed in the wind-force-resisting system quality-assurance plan prepared by a state licensed Engineer approved by Owner.

- E. Testing Agency Qualifications: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.

1.06 CONTRACTOR'S QUALITY-CONTROL PLAN:

- A. Quality-Control Plan, General: Submit quality-control plan within 30 days of Notice to Proceed, and not less than five days prior to preconstruction conference. Submit in format acceptable to Engineer. Identify personnel, procedures, controls, instructions, tests, records, and forms to be used to carry out Contractor's quality-assurance and quality-control responsibilities. Coordinate with Contractor's construction schedule.
- B. Quality-Control Personnel Qualifications: Engage qualified full-time personnel trained and experienced in managing and executing quality-assurance and quality-control procedures similar in nature and extent to those required for Project.
 - 1. Project quality-control manager may also serve as Project superintendent.
- C. Submittal Procedure: Describe procedures for ensuring compliance with requirements through review and management of submittal process. Indicate qualifications of personnel responsible for submittal review.
- D. Testing and Inspection: In quality-control plan, include a comprehensive schedule of Work requiring testing or inspection, including the following:
 - 1. Contractor-performed tests and inspections including subcontractor-performed tests and inspections. Include required tests and inspections and Contractor-elected tests and inspections.
 - 2. Special inspections required by authorities having jurisdiction and indicated on the "Statement of Special Inspections."
- E. Continuous Inspection of Workmanship: Describe process for continuous inspection during construction to identify and correct deficiencies in workmanship in addition to testing and inspection specified. Indicate types of corrective actions to be required to bring work into compliance with standards of workmanship established by Contract requirements and accepted mockups.
- F. Monitoring and Documentation: Maintain testing and inspection reports including log of accepted and rejected results. Include work Engineer has indicated as nonconforming or defective. Indicate corrective actions taken to bring nonconforming work into compliance with requirements. Comply with requirements of authorities having jurisdiction.

1.07 REPORTS AND DOCUMENTS:

A. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:

1. Date of issue.
2. Project title and number.
3. Name, address, and telephone number of testing agency.
4. Dates and locations of samples and tests or inspections.
5. Names of individuals making tests and inspections.
6. Description of the Work and test and inspection method.
7. Identification of product and Specification Section.
8. Complete test or inspection data.
9. Test and inspection results and an interpretation of test results.
10. Record of temperature and weather conditions at time of sample taking and testing and inspecting.
11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
12. Name and signature of laboratory inspector.
13. Recommendations on retesting and reinspecting.

B. Manufacturer's Technical Representative's Field Reports: Prepare written information documenting manufacturer's technical representative's tests and inspections specified in other Sections. Include the following:

1. Name, address, and telephone number of technical representative making report.
2. Statement on condition of substrates and their acceptability for installation of product.
3. Statement that products at Project site comply with requirements.
4. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
5. Results of operational and other tests and a statement of whether observed performance complies with requirements.

6. Statement whether conditions, products, and installation will affect warranty.
 7. Other required items indicated in individual Specification Sections.
- C. Factory-Authorized Service Representative's Reports: Prepare written information documenting manufacturer's factory-authorized service representative's tests and inspections specified in other Sections. Include the following:
1. Name, address, and telephone number of factory-authorized service representative making report.
 2. Statement that equipment complies with requirements.
 3. Results of operational and other tests and a statement of whether observed performance complies with requirements.
 4. Statement whether conditions, products, and installation will affect warranty.
 5. Other required items indicated in individual Specification Sections.
- D. Permits, Licenses, and Certificates: For Owner's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.08 QUALITY ASSURANCE:

- A. General: Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated.

- F. Specialists: Certain Specification Sections require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
1. Requirements of authorities having jurisdiction shall supersede requirements for specialists.
- G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E329; and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.
- H. Manufacturer's Technical Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- I. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- J. Mockups: Before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed Work:
1. Build mockups in location and of size indicated or, if not indicated, as recommended by Engineer.
 2. Notify Engineer seven days in advance of dates and times when mockups will be constructed.
 3. Employ supervisory personnel who will oversee mockup construction. Employ workers that will be employed during the construction at Project.
 4. Demonstrate the proposed range of aesthetic effects and workmanship.
 5. Obtain Engineer's acceptance of mockups before starting work, fabrication, or construction.
 - a. Allow seven days for initial review and each re-review of each mockup.
 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 7. Demolish and remove mockups when directed unless otherwise indicated.

- K. Copies of applicable referenced standards are not included in the Contract Documents. Where copies of standards are needed by the Contractor for superintendence and quality control of the work, the Contractor shall obtain a copy or copies directly from the publication source and maintain at the jobsite, available to the Contractor's personnel, subcontractors, and Engineer
- L. Quality of Materials: Unless otherwise specified, all materials and equipment furnished for permanent installation in the Work shall conform to applicable standards and specifications and shall be new, unused, and free from defects and imperfections, when installed or otherwise incorporated in the Work. The Contractor shall not use material and equipment for any purpose other than that intended or specified unless the Engineer authorizes such use.
- M. Where so specified, products or workmanship shall also conform to the additional performance requirements included within the Contract Documents to establish a higher or more stringent standard or quality than that required by the referenced standard.

1.09 OFFSITE INSPECTION:

- A. When the specifications require inspection of materials or equipment during the production, manufacturing, or fabricating process, or before shipment, such services shall be performed by the Owner's independent testing laboratory, or inspection organization acceptable to Engineer in conjunction with or by the Engineer.
- B. The Contractor shall give appropriate written notice to the Engineer not less than 30 days before offsite inspection services are required, and shall provide for the producer, manufacturer, or fabricator to furnish safe access and proper facilities and to cooperate with inspecting personnel in the performance of their duties.

1.10 MATERIALS AND EQUIPMENT:

- A. The Contractor shall maintain control over procurement sources to ensure that materials and equipment conform to specified requirements in the Contract Documents.
- B. The Contractor shall comply with manufacturer's printed instructions regarding all facets of materials and/or equipment movement, storage, installation, testing, startup, and operation. Should circumstances occur where the contract documents are more stringent than the manufacturer's printed instructions, the Contractor shall comply with the specifications. In cases where the manufacturer's printed instructions are more stringent than the contract documents, the Contractor shall advise the Engineer of the disparity and conform to the manufacturer's printed instructions. In either case, the Contractor is to apply the more stringent specification or recommendation, unless accepted otherwise by the Engineer.

1.11 QUALITY CONTROL:

A. Contractor Responsibilities: Tests and inspections not explicitly assigned to Owner are Contractor's responsibility. Perform additional quality-control activities required to verify that the Work complies with requirements, whether specified or not.

1. Unless otherwise indicated, provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.
2. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.
3. Comply with manufacturers' instructions, including each step in sequence.
4. When manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.
5. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
6. Perform Work by persons qualified to produce required and specified quality.
7. Verify field measurements are as indicated on Shop Drawings or as instructed by manufacturer.
8. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.
9. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these quality-control services.
 - a. Contractor shall not employ same entity engaged by Owner, unless agreed to in writing by Owner.
10. Notify testing agencies at least 24hours in advance of time when Work that requires testing or inspecting will be performed.
11. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
12. Testing and inspecting requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
13. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

B. Tolerances:

1. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.
 2. Comply with manufacturers' tolerances. When manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.
 3. Adjust products to appropriate dimensions; position before securing products in place.
- C. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Division 01 Section "Submittals."
- D. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in preinstallation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.
- E. Retesting/Reinspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents.
- F. Testing Agency Responsibilities: Cooperate with Engineer and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
1. Notify Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
 2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.
 3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
 4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
 5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
 6. Do not perform any duties of Contractor.
- G. Associated Services: Cooperate with agencies performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested.

Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:

1. Access to the Work.
 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.
 4. Facilities for storage and field curing of test samples.
 5. Delivery of samples to testing agencies.
 6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
 7. Security and protection for samples and for testing and inspecting equipment at Project site.
- H. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
1. Schedule times for tests, inspections, obtaining samples, and similar activities.
- I. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents as a component of Contractor's quality-control plan. Coordinate and submit concurrently with Contractor's construction schedule. Update as the Work progresses.
1. Distribution: Distribute schedule to Owner, Engineer, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify existing site conditions and substrate surfaces are acceptable for subsequent Work. Beginning new Work means acceptance of existing conditions.

- B. Verify existing substrate is capable of structural support or attachment of new Work being applied or attached.
- C. Examine and verify specific conditions described in individual specification sections.
- D. Verify utility services are available, of correct characteristics, and in correct locations.

3.02 PREPARATION:

- A. Clean substrate surfaces prior to applying next material or substance.
- B. Seal cracks or openings of substrate prior to applying next material or substance.
- C. Apply manufacturer required or recommended substrate primer, sealer, or conditioner prior to applying new material or substance in contact or bond.

3.03 QUALITY CONTROL:

- A. Quality control is the responsibility of the Contractor, and the Contractor shall maintain control over construction and installation processes to assure compliance with specified requirements.
- B. Certifications for personnel, procedures, and equipment associated with special processes (e.g., welding, cable splicing, instrument calibration, surveying) shall be maintained in the Contractor's field office, available for inspection by the Engineer. Copies shall be made available to the Engineer upon request.
- C. Means and methods of construction and installation processes are the responsibility of the Contractor, and at no time is it the intent of the Engineer to supersede or void that responsibility.

3.04 TEST AND INSPECTION LOG:

- A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:
 - 1. Date test or inspection was conducted.
 - 2. Description of the Work tested or inspected.
 - 3. Date test or inspection results were transmitted to Engineer.
 - 4. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Engineer's reference during normal working hours.

3.05 REPAIR AND PROTECTION:

- A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
 - 1. Provide materials and comply with installation requirements specified in other Specification Sections or matching existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching.
- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION

SECTION 01 43 39

MOCKUPS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Integrated exterior mockups.

1.02 DEFINITIONS

- ###### A. Integrated Exterior Mockups:
- Mockups of the exterior envelope constructed on-site as freestanding temporary built elements, consisting of multiple products, assemblies, and subassemblies.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference:

Conduct conference at Project site.

1. Meet with Owner, Engineer, testing and inspecting agency representative, and installers of major systems whose Work is included in integrated exterior mockups.
2. Review coordination of equipment and furnishings provided by the Owner for room mockups.
3. Review locations and extent of mockups.
4. Review testing procedures to be performed on mockups.
5. Review and finalize schedule for mockups, and verify availability of materials, personnel, equipment, and facilities needed to complete mockups and maintain schedule for the Work.

1.04 ACTION SUBMITTALS

A. Shop Drawings:

For integrated exterior mockups.

1. Include plans, elevations, sections, and support details.
2. Indicate manufacturer and model number of individual components, subassemblies, and assemblies.
3. Include site location drawing indicating orientation of mockup.

4. Revise and resubmit Shop Drawings to reflect approved modifications in details and component interfaces resulting from changes made during testing procedures.

B. Delegated Design Submittal: For temporary structural supports for mockups not attached to building structure, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.05 QUALITY ASSURANCE

A. Build mockups to do the following:

1. Verify selections made under Sample submittals.
2. Demonstrate aesthetic effects.
3. 3. Demonstrate the qualities of products and workmanship.
4. 4. Demonstrate acceptable coordination between components and systems.

B. Fabrication: Before fabricating or installing portions of the Work requiring mockups, build mockups for each form of construction and finish required. Use materials and installation methods as required for the Work.

1. Build mockups of size indicated.
2. Build mockups in location indicated or, if not indicated, as directed by Engineer.
3. Employ supervisory personnel who will oversee mockup construction. Employ workers who will be employed to perform same tasks during the construction at Project.
4. Demonstrate the proposed range of aesthetic effects and workmanship.
5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
6. Demolish and remove mockups when directed unless otherwise indicated.

C. Notifications:

1. Notify Engineer seven days in advance of the dates and times when mockups will be constructed.
2. Allow seven days for initial review and each re-review of each mockup.

D. Approval: Obtain Engineer's approval of mockups before starting fabrication or construction of corresponding Work.

1. Unless otherwise indicated, approved mockups establish the standard by which the Work will be judged.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.06 COORDINATION

- A. Coordinate schedule for construction of mockups, so construction, testing, and review of mockups do not impact Project schedule.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design support structure for free-standing mockups.
- B. Structural Performance:
 1. Seismic Performance: Mockups and support structure to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
 2. Wind Loads: As indicated on Drawings.

2.02 INTEGRATED EXTERIOR MOCKUPS

- A. Construct integrated exterior mockups as indicated on Drawings or when requested by Owner or Engineer. Construct mockups to demonstrate constructability, coordination of trades, and sequencing of Work; and to ensure materials, components, subassemblies, assemblies, and interfaces integrate into a system complying with indicated performance and aesthetic requirements.
- B. Design and construct foundation and superstructure to support free-standing integrated exterior mockups.
- C. Build integrated exterior mockups using installers and construction methods that will be used in completed construction.
- D. Use specified products that have been approved by Engineer. Coordinate installation of materials and products specified in individual Specification Sections that include Work included in integrated exterior mockups.

- E. The Work of integrated exterior mockups includes, but is not limited to, the following:
1. Masonry veneer and mortar.
 2. Applied water repellents.
 3. Through-wall flashing.
 4. Flashing and sheet metal trim, including coping.
 5. Joint sealants.
 6. Metal wall panels.
 7. Aluminum-framed entrances and storefront.
 8. Glazing.
 9. Louvers.
- F. Photographic Documentation: Document construction of integrated exterior mockups with photographs. Provide photographs showing details of interface of different materials and assemblies.
- G. Provide and document modifications to construction details and interfaces between components and systems required to properly sequence the Work, or to pass performance testing requirements. Obtain Engineer's approval for modifications.
- H. Retain approved mockups constructed in place. Incorporate fully into the Work.

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01 45 33

STRUCTURAL TESTS AND INSPECTIONS

PART 1 - GENERAL

1.01 GENERAL:

- A. The Structural Engineer of Record (SER) is the Structural Engineer (an individual) who is in responsible charge of the preparation of the structural drawings and structural specifications for this project and whose professional engineering seal appears on said structural drawings.
- B. The Program of Structural Tests and Inspections which has been or will be submitted to the building official who has jurisdiction over this project is included at the end of this Section.
- C. The Structural Tests and Inspections shall not relieve the Contractor or its subcontractors of their responsibilities and obligations for quality control of the Work, their other obligations for supervising the work, for any design work, which is included in their scope of services, and for full compliance with the requirements of the Contract Documents. The detection of, or failure to detect, deficiencies or defects in the Work during the testing and inspection conducted pursuant to the Structural Tests and Inspections shall not relieve the Contractor or its subcontractors of their responsibility to correct all deficiencies or defects, whether detected or undetected, in all parts of the Work, and to otherwise comply with all requirements of the Contract Documents. Further, while the SER, and the Resident Project Representative shall perform certain tasks in the Program requiring the review of certain construction activities, the SER and Resident Project Representative shall only perform such tasks to ensure compliance with the SER approved submittals and the specifications. Neither the SER nor the Resident Project Representative shall assume any responsibility or liability for the means, methods, procedures or techniques used by any construction contractor.
- D. The Program of Structural Tests and Inspection does not apply to the Contractor's equipment, temporary structures used by the Contractor to construct the project, the Contractor's means, methods, and procedures, and job site safety.

1.02 CONTRACTOR'S RESPONSIBILITIES:

- A. Where the Program of Structural Tests and Inspections (Attachment No. 1 of 01 45 33) indicates that a structural component or system is subject to structural tests and inspections and that the SER for the project has not been retained to design said component or system or to prepare a performance specification for said component of system, the Contractor shall retain, or require others under his aegis to retain, a professional engineer registered in the jurisdiction where the project is located to design said component or system and to provide the required program of structural tests and inspections for said component or system.

- B. The Contractor shall provide free and safe access to the Work for the SER and all other individuals who are observing the Work or performing structural tests or inspections. The Contractor shall provide all ladders, scaffolding, staging, and up-to-date safety equipment, all in good and safe working order, and qualified personnel to handle and erect them, as may be required for safe access.
- C. The Contractor shall be responsible for all scheduling and coordination of Owner and Contractor's Testing Laboratory Services to comply with testing frequencies and tests required as indicated in the Contract Documents.
- D. Building permit applications are submitted by the Engineer. Inspections required for the project by the building department must additionally be requested by the Contractor. Engineer shall not be responsible for scheduling building department inspections. Engineer and Owner shall not be responsible for any additional costs or delays to the project caused from Contractor delay in getting or requesting building department inspections.
 - 1. Any costs associated with rework or removal to allow access/inspection by building department shall be at Contractor expense.

1.03 CONTRACTOR FURNISHED TESTING LABORATORY SERVICES:

- A. An independent commercial testing laboratory acceptable to the Engineer shall perform all tests that require the services of a laboratory to determine compliance with the Contract Documents. The laboratory shall be staffed with experienced technicians, properly equipped, and fully qualified to perform the tests in accordance with the specified standards.
- B. Preliminary Testing Services: The Contractor shall be responsible for all testing laboratory services in connection with concrete materials and mix designs, the design of asphalt mixtures, gradation tests for structural and embankment fills, backfill materials, and all other tests and engineering data required for the Engineer's review of materials and equipment proposed to be used in the Work. The Contractor shall obtain the Engineer's acceptance of the testing laboratory before having services performed, and shall pay all costs for services.
- C. The Contractor shall not retain any testing laboratory against which the Owner or the Engineer have reasonable objection, and if at any time during the construction process the services become unacceptable to the Owner, or the Engineer, either the Owner or the Engineer may direct in writing that such services be terminated. The request must be supported with evidence of improper testing or unreasonable delay. If the Engineer determines that sufficient cause exists, the Contractor shall terminate the services and engage a different testing laboratory.
- D. Transmittal of Test Reports: Written reports of testing and engineering data furnished by the Contractor for the Engineer's review of materials and equipment proposed to be used in the Work shall be submitted as specified for Shop Drawings.

- E. The Contractor's testing laboratory shall furnish four copies of a written report of each test performed by laboratory personnel within three days after each test is completed. Distribution shall be two copies of each test report to the Engineer's Representative, one copy to the Owner, and one copy for the Contractor.

1.04 OWNER FURNISHED TESTING AND INSPECTION SERVICES:

- A. The Owner will employ the services of an independent testing agency to conduct the Program of Structural Tests and Inspections as described in Section 01 45 33 and perform all quality control tests of materials of construction in the field or in the laboratory during and after their incorporation in the Work. Field sampling and testing shall be performed in the general manner indicated in the specifications, with minimum interference with construction operations.
- B. The Contractor shall furnish a construction schedule and a minimum of 48 hour notice of readiness for testing and inspection of the work. The Engineer shall determine the exact time and location of field sampling and testing, and may require such additional sampling and testing as necessary to determine that materials and equipment conform with data previously furnished by Contractor and with the Contract Documents.
- C. The Contractor shall schedule the work to permit adequate time for testing and re-testing should test results not conform to the contract documents. Lack of testing or inspection which is attributable to insufficient notice by the Contractor or failure of the Contractor to cooperate, will be cause for rejection of the work.
- D. The Contractor shall deliver materials in sufficient quantities to the Owner's testing agency as may be required. Laboratory testing shall be performed within a reasonable time, consistent with the specified standards.
- E. The Contractor shall furnish material samples and cooperate in the field sampling and testing activities, interrupting the work when necessary. The Contractor shall furnish personnel, facilities and access to assist in the sampling and testing activities.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

ATTACHMENT NO. 1
PROGRAM OF STRUCTURAL TESTS AND INSPECTIONS

Project: Provo River Water Treatment Plant

Location: 2025 North Freedom Blvd, Provo UT

Owner: Provo City Corporation

Owner's Address: 1377 South 350 East, Provo, UT 84606

Architect of Record: Jim Singletary, AECOM

Structural Engineer of Record (SER): Robert E. Hawthorne, AECOM

This program of structural tests and inspections is submitted as a condition for issuance of the building permit in accordance with the International Building Code 2018.

The following firms, agencies, or individuals (hereinafter referred to collectively as agents) will perform the tests and inspections under the direction of the SER:

<u>Abbreviation</u>	<u>Agent</u>
SER	Structural Engineer Of Record Listed Above
RES	The Resident Representative
ITA	Independent Testing Agency Employed By Owner
ITA(C)	Independent Testing Agency Employed By Contractor
RPE(C)	Registered Professional Engineer Employed by Contractor
GEO	The Project Geotechnical Engineer
IWI	Independent Welding Inspector

The above abbreviations will be used on the attached pages to identify which agent is performing the particular tests or inspections.

The following categories of structural tests and inspections, if checked, are included in the Program for Structural Tests and Inspections for this project. The specific tests and inspections required for each checked category are listed on the page noted opposite the category and further described in the various technical specification sections.

<u>Category</u>	<u>Page</u>	<u>Category</u>	<u>Page</u>
<input checked="" type="checkbox"/> Steel Construction	6	<input checked="" type="checkbox"/> Controlled Structural Fill	12
<input checked="" type="checkbox"/> Cast-in-Place Concrete	7	<input type="checkbox"/> Pile Foundations	13
<input checked="" type="checkbox"/> Precast Concrete Construction	8	<input type="checkbox"/> Drilled Pier Foundations	14
<input checked="" type="checkbox"/> Masonry Construction	10	<input checked="" type="checkbox"/> Aluminum Construction	15
<input checked="" type="checkbox"/> In-Situ Bearing Strata for Foundations	11	<input type="checkbox"/> Special Cases	16

The following items of construction, if checked, are specified in the structural plans or specifications on a performance basis. The structural design of these items will be performed by the RPEC and reviewed by the SER. The construction of these items is included in the program for tests and inspections on the attached sheets.

<u>Category</u>	<u>Category</u>
<input type="checkbox"/> Curtain Walls	<input type="checkbox"/> Metal Buildings
<input checked="" type="checkbox"/> Precast Concrete Components	<input checked="" type="checkbox"/> Metal Stairs
<input type="checkbox"/> Post-Tensioning Steel	<input checked="" type="checkbox"/> Metal Railings
<input checked="" type="checkbox"/> Structural Steel Connections	<input checked="" type="checkbox"/> Metal and Composite Gratings
<input type="checkbox"/> Structural Aluminum Connections	<input type="checkbox"/> Metal Plate Covers

The following items are excluded from this program of structural tests and inspections, since other structural engineers not under the aegis of the SER designed them and the SER has no duties or responsibilities with respect to such performance specifications or designs. The Owner shall assign other architects, or construction contractors, as applicable; to be special SER's for their respective designs and such architects and/or contractors shall be responsible for all such structural tests and inspections for their respective designs.

- Wind and seismic design of mechanical or electrical components, systems and their anchorage to the structure.
- Excavation support systems.
- Temporary bracing, temporary platforms, scaffolding, temporary guards and railings.
- Anything related to jobsite safety or construction means and methods.
- Ground improvements.

Structural Engineer of Record:

Name: Robert E. Hawthorne

Signature: _____

Firm: AECOM

Date: _____

Registration Seal

STEEL CONSTRUCTION

Item	Agent	Scope	Frequency
1. Fabricator Certification/ Quality Control Procedures.	SER	Review to ensure that quality control procedures have been adopted for each Fabricator.	Start of project
2. Fabricator Inspection	SER	Review to ensure that an Independent Inspection Agency has approved each Fabricator.	Start of project
3. Material Certification	SER	Review for conformance to the specifications.	Each produce
4. Bolting	ITA	Test and inspect bolted connections in accordance with specifications. Verify bolt size and grade in accordance with AISC specifications A325/A490.	Periodic
5. Welding	IWI	Check welder qualifications. Verify filler material in accordance with AWS D1.1. Visually inspect fillet welds. Test complete and partial penetration groove welds full length by dye penetrant, ultrasonic, or radiographic testing in accordance with the contract documents.	Periodic
6. Shear Connectors	IWI	Inspect for size and placement. Test for proper weld attachment.	Periodic
7. Structural Framing, Details and Assemblies	RES	Review for conformance with specifications and shop drawings.	Continuous
8. Open Web Steel Joists	RES	Inspect for size, placement, bridging, bearing and connection to structure.	Continuous
9. Open Web Steel Joists	IWI	Visually inspect all welds of a minimum of 5 percent of the joists, randomly selected.	Periodic
10. Steel Decking	RES/ IWI	Verify gage, width, and type. Inspect placement, laps, welds, side lap attachment and screws or other mechanical fasteners (IWI). Check welder qualifications (RES).	Periodic

CAST-IN-PLACE CONCRETE CONSTRUCTION

Item	Agent	Scope	Frequency
1. Mix Design	ITA(C)	Design concrete mixes	Each mix
	SER	Review mix designs.	Each mix
2. Materials Certification	SER	Review for conformance to specifications.	Each product
3. Batching Plant	ITA/SER	Review to ensure that Plant quality control procedures have been adopted.	Start of project
4. Reinforcement Installation	RES	Inspect reinforcing for size, quantity, condition and placement.	Prior to each placement
5. Formwork Geometry	RES	Inspect form sizes for compliance with specifications.	Prior to each placement
6. Concrete Placement	RES	Review for conformance with specifications.	Each placement
	ITA	Perform slump, density and air content tests at point of discharge.	Each truck
7. Curing and Protection	ITA/RES	Observe procedures for conformance to the specifications.	Each placement
8. Evaluation of Concrete Strength	ITA	Test and evaluate in accordance with the specifications.	Every 50 cubic yards or part thereof
Note: The Contractor may elect to have the Contractor's independent testing agency (ITA(C)) perform additional tests in addition to the testing by the Owner's Independent Testing Agency (ITA) at no cost to the Owner.			

PRECAST CONCRETE CONSTRUCTION

Item	Agent	Scope	Frequency
1. Plant Certification/Quality Control Procedures	SER/ ITA	Review to ensure that Plant quality control procedures have been adopted (SER). Inspect plant storage and handling procedures (ITA). Confirm that approved submittals are being used for fabrication; review welder's certifications (SER). Monitor finished product for structural defects (cracks) (ITA).	Start of project
2. Material Certification	SER	Review for conformance to ACI 318.	Each product
3. Formwork Geometry	ITA	Inspect form sizes.	Selected placements
4. Reinforcement Installation	ITA	Inspect reinforcing and prestressing strands for size, quantity, condition and placement for conformance with Contract Documents, SER approved submittals, and ACI 318. Inspect welding.	Selected placements
5. Mix Design	ITA(C)	Design concrete mixes	Each mix
	SER	Review for conformance with specifications (SER).	Each mix
6. Concrete Placement	RES/ ITA	Inspect concrete placement procedures for conformance to ACI 318, Sections 5.9 and 5.10 (ITA), and for conformance with specifications (RES).	Selected placements
7. Curing and Protection	RES/ ITA	Inspect for maintenance of specified curing temperatures and techniques per ACI 318 (ITA), and for conformance with specifications (RES).	Each placement
8. Evaluation of Concrete Strength	ITA	Test for conformance to specifications in accordance with ACI 318.	Every 50 cubic yards or part thereof
9. Prestress Operation	ITA	Inspect application of prestressing forces per ACI 318. Inspect grouting of bonded, post-tensioned, prestressing tendons.	Selected placements

Item	Agent	Scope	Frequency
10. Assembled/Erected Precast Elements.	RES	Inspect for compliance with SER approved submittals and specifications. Review site storage and handling procedures for consistency with design of precast elements. Verify that SER approved erection drawings are on site and are being used for erection. Verify that SER approved erection procedures are being followed. . Review welder's certifications.	Each unit
11. Connections/ Embedded Items	ITA	Inspect interface connections including end and edge doweling. Inspect embedment for proper location. Inspect shimming, bearing, bolting and welding of connections.	Each unit

MASONRY CONSTRUCTION

Item	Agent	Scope	Frequency
1. Material Certification	SER	Review for conformance to specifications.	Each product
2. Evaluation of Masonry Strength	ITA	Verify strength in accordance with the specifications.	Periodic
3. Proportioning, Mixing and Consistency of Mortar and Grout	ITA	Inspect field-mixing procedures for conformance to the specifications.	Continuous
4. Installation of Masonry	RES	Inspect placement for conformance to the specifications.	Continuous
5. Reinforcement Installation	RES/ IWI	Inspect reinforcing steel for conformance to SER approved submittals and specifications (RES) Inspect welding of reinforcement and review welder's certifications (IWI).	Periodic
6. Grouting Operations	RES	Review grouting procedures for conformance with the specifications.	Periodic
7. Weather Protection	RES	Review procedures for protection for cold and hot weather for conformance with the specifications.	Periodic
8. Anchorage	RES	Inspect anchorage of masonry to other construction for conformance with specifications.	Periodic

IN-SITU BEARING STRATA FOR FOUNDATIONS

Item	Agent	Scope	Frequency
1. Bearing strata for foundations	GEO/ RES	Review strata for conformance to the structural drawings, specifications, and/or geotechnical report.	Prior to foundation placement
2. Bearing surfaces of foundations	GEO/RES	Review for conformance to the requirements of the structural drawings, specifications, and/or geotechnical report.	Prior to foundation placement

CONTROLLED STRUCTURAL FILL (PREPARED FILL)

Item	Agent	Scope	Frequency
1. Fill Material	ITA	Test material for conformance to specifications or geotechnical report. Perform laboratory compaction tests in accordance with the specifications to determine optimum water content and maximum dry density.	Each material
2. Installation of Controlled Structural Fill	RES/ ITA	Provide review of the installation, in accordance with the specifications. Verify maximum lift placement thickness (ITA).	Each lift
3. Density of Fill	ITA	Perform field density tests of the in-place fill in accordance with the specifications.	Each lift
NOTE: Above testing is confirmatory testing by the Owner's Independent Testing Agency (ITA). These tests are <u>in addition</u> to the testing required by the Contractor's independent testing agency (ITA(C)).			

PILE FOUNDATIONS

Item	Agent	Scope	Frequency
1. Pile Material	SER/ RES	Review for conformance with the specifications, and that the identification is maintained from the point of manufacture to the point of delivery to the site.	Each pile shipment
2. Pile Material Tests	ITA	If Item 1 is unsatisfactory, test material for conformance to the Contract Documents.	As required
3. Precast Concrete Piles.	-	Perform structural tests and inspections as listed under Precast Concrete Construction.	See precast concrete requirements
4. Steel Piles	-	Perform structural test and inspections as listed under Steel Construction.	See steel construction requirements
5. Pile Installation	RES/ GEO	Provide review for conformance with specifications. Maintain accurate records for each pile. Record final location of each pile in plan.	Continuous
6. Cast-in-Place Concrete Piles	-	Perform structural tests and inspections as listed under Cast-in-Place Concrete Construction.	See cast-in-place concrete construction
Note: Additional confirmatory observations and/or testing by the Owner's independent testing agency (ITA) <u>in addition</u> to the observations and testing required by the Contractor's independent testing agency (ITA(C)) and the Contractor's registered professional engineer (RPE(C)) may be performed at the Owner's discretion.			

DRILLED PIER FOUNDATIONS

Item	Agent	Scope	Frequency
1. Load-bearing Steel Components	SER	Review documents identifying material and certifying grade of material for conformance to the specifications	Each component
2. Concrete and Reinforcing Steel Components	-	Perform structural tests and inspections as listed under Cast-in-Place Concrete Construction.	See concrete requirements
3. Pier installation	RES	Provide review of installation for conformance with specifications. Maintain accurate records for each pier, documenting observations.	Continuous

ALUMINUM CONSTRUCTION

Item	Agent	Scope	Frequency
1. Fabricator Certification/ Quality Control Procedures.	SER	Review to ensure that quality control procedures have been adopted for each Fabricator.	Start of project
2. Fabricator Inspection	SER	Review to ensure that an Independent Inspection Agency has approved each Fabricator.	Start of project
3. Material Certification	SER	Review for conformance to the specifications.	Each product
4. Bolting	ITA	Test and inspect bolted connections in accordance with specifications. Verify bolt size and grade in accordance with AISC specifications A325/A490.	Periodic
5. Welding	IWI	Check welder qualifications. Verify filler material in accordance with AWS D1.1. Visually inspect fillet welds. Test complete and partial penetration groove welds full length by dye penetrant, ultrasonic, or radiographic testing in accordance with the contract documents.	Periodic
6. Structural Framing, Details and Assemblies	RES	Review for conformance with specifications and shop drawings.	Periodic

SPECIAL CASES

Item	Agent	Scope	Frequency
1. Rock Anchors	RES	Witness testing in accordance with contract documents.	Each anchor
2. Pressure Relief Valves	RES	Verify that quantity, location and details conform to SER approved submittals and specifications.	Each valve
3. Tank Leakage Testing	RES	Witness testing in accordance with contract documents.	Each tank
4. Concrete Anchor Installation	RES	Verify diameters, depth and cleaning of holes conforms to manufacturer's instructions.	Each anchor

END OF SECTION

SECTION 01 50 00
TEMPORARY FACILITIES

PART 1 - GENERAL

1.01 SCOPE OF WORK:

- A. The Contractor shall provide all temporary facilities for the proper completion of the work as indicated and in compliance with Contract Documents.

1. Section Includes:

- a. Use Charges:
 - (1) Sewer.
 - (2) Water.
 - (3) Electric.
 - (4) Temporary heat.
- b. Project identification.
- c. Traffic regulation.
- d. Temporary Facilities:
 - (1) Field offices and sheds.
 - (2) Office for Engineer.
- e. Equipment.
- f. Support facility installation.
- g. Security and Protection:
- h. Operation, termination, and removal.

1.02 REFERENCES:

- A. American National Standards Institute (ANSI):
- 1. A 117.1: Accessible and Usable Buildings and Facilities.
- B. American Society for Testing and Materials (ASTM):

1. E84: Standard Test Method for Surface Burning Characteristics of Building Materials
2. E136: Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 deg. C.

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code
2. 241: Standard of Safeguarding Construction, Alteration, and Demolition Operations
3. 701: Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

1.03 USE CHARGES:

A. General: Costs for installation, removal and use of temporary facilities shall be included in the Contract Sum unless otherwise indicated. Allow other entities to use temporary services and facilities without cost, including, but not limited to, Owner's project team, Engineer, testing agencies, and authorities having jurisdiction.

B. Sewer Service: Pay sewer-service use charges for sewer usage by all entities for construction operations.

1. The Contractor shall provide adequate sanitary facilities for the use of those employed on the Work. Such facilities shall be made available when the first employees arrive on the site of the Work, shall be properly secluded from public observation, and shall be constructed and maintained during the progress of the Work in suitable numbers and at such points and in such manner as may be required by pertinent health and safety regulations.
2. The Contractor shall maintain the sanitary facilities in a satisfactory and sanitary condition at all times and shall enforce their use. He shall rigorously prohibit the committing of nuisances on the site of the Work, on the lands of the Owner, or on adjacent property.

a. The Contractor shall not use the Owner's sanitary facilities.

C. Potable Water Service: Pay water-service use charges for potable water used by all entities for construction operations.

1. For all necessary operations at the site of the work (except as noted in the next paragraph below) the Owner, without charge therefor, shall provide reasonable quantities of water at the then existing pressure from a mutually convenient hydrant of the water distribution system. The Contractor shall furnish all necessary pipe or hose extensions to conduct the water to the points of use and shall exercise due care not to waste water. The Contractor shall not contaminate the water supply

and shall comply with all applicable regulations and code requirements. Contractor shall supply and install a meter to monitor water use. The Owner retains the right to restrict or limit water use.

2. The Owner reserves the right to limit, suspend, or terminate the supplying of water as set forth above should it consider such action to be necessary on account of damage to the distribution system, the necessity of conserving water, or other emergency. In this event, the Contractor shall obtain water from some other approved source, at his own expense.
- D. Electric Power Service: Pay electric-power-service use charges for electricity used by all entities for construction operations.
1. The Contractor shall make all necessary applications and arrangements and pay all fees and charges for electrical energy for power and light necessary for the proper completion of the Work and during its entire progress. The Contractor shall provide and pay for all temporary wiring, switches, connections, and meters.
 2. The Contractor shall provide sufficient electric lighting so that all work may be done in a workmanlike manner when there is not sufficient daylight.
- E. Notwithstanding the availability of potable water from the existing system, the Contractor shall be solely responsible for the provision of water for leakage and other testing, for concrete protection and to prevent freezing of equipment, as required by the Contract.
- F. Temporary Heat:
1. If temporary heat is required for the protection of the Work, the Contractor shall provide and install suitable heating apparatus, shall provide adequate and proper fuel, and shall maintain heat as required. Costs for temporary heating, cooling, and ventilating required to execute the Work shall be borne by the Contractor.
 2. Temporary heating apparatus shall be installed and operated in such manner that finished work will not be damaged thereby. After the permanent heating system has been installed, tested, and made ready for operation, the Contractor may, at his own risk and expense, use it for providing heat for protection of the Work. He shall provide and pay for all fuel and care necessary, and, when the Work is ready for acceptance, he shall, at his own expense, put the system into first-class condition, even to the extent of replacing worn or damaged parts.
 3. If permanent natural gas piping is used for temporary heating units, the Contractor shall not modify or reroute gas piping without the prior approval of the natural gas supplier. The Contractor shall provide separate gas metering as required by the natural gas supplier.
 4. The Contractor shall provide 24-hour monitoring of temporary heating, cooling and ventilating equipment.

1.04 PROJECT IDENTIFICATION:

A. Project Identification Sign:

1. Painted sign of construction, design, and content shown on Drawings. Sign content to be reviewed and approved by Owner.

B. Project Informational Signs:

1. Painted informational signs of same colors and lettering as Project Identification sign, or standard products; size lettering for legibility at 100 foot distance.
2. Provide at each field office, storage shed, and directional signs to direct traffic into and within site. Relocate as Work progress requires.
3. Provide municipal traffic agency directional traffic signs to and within site.
4. No other signs are allowed without Owner permission except those required by law.

C. Design sign and structure to withstand 60 miles/hr wind velocity.

D. Sign Company: Experienced as professional sign company for minimum three years.

E. Finishes, Painting: Adequate to withstand weathering, fading, and chipping for duration of construction.

F. Show content, layout, lettering, color, structure, and grades of members.

G. Sign Materials:

1. Structure and Framing: Wood or metal, structurally adequate.
2. Sign Surfaces: Exterior grade plywood with medium density overlay, minimum 3/4 inch thick, standard large sizes to minimize joints.
3. Rough Hardware: Galvanized.
4. Paint and Primers: Exterior quality, two coats; sign background of white.
5. Lettering: Exterior quality paint, contrasting colors as selected.

H. Installation:

1. Install project identification sign within 15 days after date fixed by Notice to Proceed and with Owners approval.
2. Erect at location of high public visibility adjacent to main entrance to site.

3. Erect supports and framing on secure foundation, rigidly braced and framed to resist wind loadings.
 4. Install sign surface plumb and level, with butt joints. Anchor securely.
 5. Paint exposed surfaces of sign, supports, and framing.
- I. Maintenance: Maintain signs and supports clean, repair deterioration and damage.
 - J. Removal: Remove signs, framing, supports, and foundations at completion of Project and restore the area.
- 1.05 TRAFFIC REGULATION:
- A. Provide that all traffic control layouts and designs comply with the Manual of Uniform Traffic Control Devices (MUTCD).
 - B. Signs, Signals, And Devices:
 1. Post Mounted and Wall Mounted Traffic Control and Informational Signs: As approved by authority having jurisdictions.
 2. Traffic Control Signals: As approved by authority having jurisdictions.
 3. Traffic Cones and Drums, Flares and Lights: As approved by authority having jurisdictions.
 4. Flagperson Equipment: As required by local jurisdictions.
 - C. Flag Persons: Provide trained and equipped flag persons to regulate traffic when construction operations or traffic encroach on public traffic lanes.
 - D. Flares and Lights: Use flares and lights during hours of low visibility to delineate traffic lanes and to guide traffic.
 - E. Haul Routes:
 1. Consult with authority having jurisdiction, establish public thoroughfares to be used for haul routes and site access.
 2. Confine construction traffic to designated haul routes.
 3. Provide traffic control at critical areas of haul routes to regulate traffic, to minimize interference with public traffic.
 - F. Traffic Signs and Signals:
 1. Provide signs approaches to site and on site, at crossroads, detours, parking areas, and elsewhere as needed to direct construction and affected public traffic.

2. Provide, operate, and maintain traffic control signals to direct and maintain orderly flow of traffic in areas under Contractor's control, and areas affected by Contractor's operations.
3. Relocate as Work progresses, to maintain effective traffic control.

G. Removal:

1. Remove equipment and devices when no longer required.
2. Repair damage caused by installation.
3. Remove post settings to depth of 2 feet.

1.06 SUBMITTALS:

- A. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.
- B. Erosion- and Sedimentation-Control Plan: Show compliance with requirements of EPA Construction General Permit or authorities having jurisdiction, whichever is more stringent.
- C. Fire-Safety Program: Show compliance with requirements of NFPA 241 and authorities having jurisdiction. Indicate Contractor personnel responsible for management of fire-prevention program.
- D. Moisture-Protection Plan: Describe procedures and controls for protecting materials and construction from water absorption and damage.
 1. Describe delivery, handling, and storage provisions for materials subject to water absorption or water damage.
 2. Indicate procedures for discarding water-damaged materials, protocols for mitigating water intrusion into completed Work, and replacing water-damaged Work.
 3. Indicate sequencing of work that requires water, and describe plans for dealing with water from these operations. Show procedures for verifying that wet construction has dried sufficiently to permit installation of finish materials.

1.07 QUALITY ASSURANCE:

- A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.
- B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

- C. Accessible Temporary Egress: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

1.08 PROJECT CONDITIONS:

- A. Temporary Use of Permanent Facilities: Engage Installer of each permanent service to assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before Owner's acceptance, regardless of previously assigned responsibilities.
- B. During adverse weather and against the possibility thereof, the Contractor shall take all necessary precautions so that the Work may be properly done and satisfactory in all respects. When required, protection shall be provided by use of tarpaulins, wood and building-paper shelters, or other suitable means.
- C. During cold weather, materials shall be preheated, if required, and the materials and adjacent structure into which they are to be incorporated shall be made and kept sufficiently warm so that a proper bond will take place and a proper curing, aging, or drying will result. Protected spaces shall be artificially heated by suitable means which will result in a moist or a dry atmosphere according to the particular requirements of the work being protected. Ingredients for concrete and mortar shall be sufficiently heated so that the mixture will be warm throughout when used.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Chain-Link Fencing: Minimum 2-inch, 0.148-inch-thick, galvanized-steel, chain-link fabric fencing; minimum 6 feet high with galvanized-steel pipe posts; minimum 2-3/8-inch- OD line posts and 2-7/8-inch- OD corner and pull posts.

2.02 TEMPORARY FACILITIES:

- A. Field Offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading.
- B. The Contractor shall maintain a temporary field office near the work for his own use during the period of construction at which readily accessible copies of all contract documents shall be kept. The office shall be located where it will not interfere with the progress of the work. There shall be a competent superintendent of the Contractor in charge of this office.
- C. Temporary Storage Yards: The Contractor shall construct temporary storage yards for storage of Products that are not subject to damage by weather conditions.
- D. Temporary Storage Buildings:

1. The Contractor shall provide environmental control systems that meet the recommendations of Suppliers and manufacturers of the equipment and materials stored.
 2. The Contractor shall arrange for a chain link partition fence to provide security of contents and ready access for inspection and inventory.
- E. The Contractor shall store combustible materials (paints, solvents, fuels) in a well ventilated and remote building meeting all applicable safety standards.

2.03 FIELD OFFICE REQUIREMENTS:

- A. In addition to Contractor staff, the field office shall provide two desk spaces for the Engineer or Owner to use while on site.
- B. The Contractor shall furnish insurance coverage of adequate amount to replace not only the Contractor's equipment, but all property belonging to the Engineer at replacement cost.
- C. The office shall have two exterior doors, with cylinder locks and keys.
- D. The Contractor shall furnish the following furniture, equipment, supplies, and services:
1. Climate controlled office space
 2. All furnishings, including but not limited to: desks, chairs, monitors, tables.
 3. Adequate interior and exterior lighting
 4. Printer: "All-in-one" unit equipped with printer server, combining color printing, photocopying, scanning, and faxing, or separate units for each of these three functions.
 5. Internet Service: Broadband modem, router and ISP, equipped with hardware firewall, providing High Speed Internet at each computer.
 6. Internet Security: Integrated software, providing software firewall, virus, spyware, phishing, and spam protection in a combined application.
- E. The Contractor shall provide office space and facilities until the office, furnishings, and equipment described above are ready for use, but by so doing he shall not be relieved of his obligation to provide and equip the specified Engineer's office as promptly as possible.
- F. Unless otherwise directed by the Engineer, after the date of completion of the Work as stated in the final estimate, the Contractor shall remove the office and all such temporary facilities from the site, the same to become his property, and leave the premises in a condition acceptable to the Engineer.

- G. Provide janitorial service with two cleanings per week.
 - H. Provide designated parking for Contractor, Engineer and Owner. Parking space provided shall be adequate to accommodate all on site personal.
 - I. Remove snow and ice as required to minimize accumulations.
 - J. Storage and Fabrication Sheds: Provide sheds sized, furnished, and equipped to accommodate materials and equipment for construction operations.
 - 1. Store combustible materials apart from building.
- 2.04 EQUIPMENT:
- A. Fire Extinguishers: Portable, UL rated; with class and extinguishing agent as required by locations and classes of fire exposures.
 - B. HVAC Equipment: Unless Owner authorizes use of permanent HVAC system, provide vented, self-contained, liquid-propane-gas or fuel-oil heaters with individual space thermostatic control.
 - 1. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.
 - 2. Heating Units: Listed and labeled for type of fuel being consumed, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL:

- A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.
- B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

3.02 TEMPORARY UTILITY INSTALLATION:

- A. General: Install temporary service or connect to existing service.
 - 1. Arrange with utility company, Owner, and existing users for time when service can be interrupted, if necessary, to make connections for temporary services.
- B. Sewers and Drainage: Provide temporary utilities to remove effluent lawfully.

1. Connect temporary sewers to municipal system as directed by authorities having jurisdiction.
- C. Water Service: Install water service and distribution piping in sizes and pressures adequate for construction.
- D. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with requirements of authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.
- E. Heating and Cooling: Provide temporary heating and cooling required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.
- F. Ventilation and Humidity Control: Provide temporary ventilation required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce ambient condition required and minimize energy consumption.
 1. Provide dehumidification systems when required to reduce substrate moisture levels to level required to allow installation or application of finishes.
- G. Electric Power Service: Provide electric power service and distribution system of sufficient size, capacity, and power characteristics required for construction operations.
 1. Install electric power service overhead unless otherwise indicated.
 2. Connect temporary service as directed by Owner.
- H. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.
 1. Install and operate temporary lighting that fulfills security and protection requirements without operating entire system.
 2. Install lighting for Project identification sign.
- I. Telephone Service: Provide temporary telephone service in common-use facilities for use by all construction personnel. Install one telephone line(s) for each field office.
 1. At each telephone, post a list of important telephone numbers.
 - a. Police and fire departments.

- b. Ambulance service.
 - c. Contractor's home office.
 - d. Contractor's emergency after-hours telephone number.
 - e. Engineer's offices.
 - f. Owner's office.
 - g. Principal subcontractors' field and home offices.
2. Provide superintendent with cellular telephone or portable two-way radio for use when away from field office.

3.03 SUPPORT FACILITIES INSTALLATION:

A. General: Comply with the following:

1. Provide construction for temporary offices, shops, and sheds located within construction area or within 30 feet of building lines that is noncombustible according to ASTM E136. Comply with NFPA 241.
2. Maintain support facilities until Engineer schedules Substantial Completion inspection. Remove before Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to Owner.

B. Temporary Roads and Paved Areas: Construct and maintain temporary roads and paved areas adequate for construction operations. Locate temporary roads and paved areas within construction limits indicated on Drawings.

1. Provide dust-control treatment that is nonpolluting and non-tracking. Reapply treatment as required to minimize dust.
2. Do not use chemical means of dust control without prior written approval from the Engineer. The use of petroleum products will not be allowed at any time.

C. Temporary Use of Permanent Roads and Paved Areas: Locate temporary roads and paved areas in same location as permanent roads and paved areas. Construct and maintain temporary roads and paved areas adequate for construction operations. Extend temporary roads and paved areas, within construction limits indicated, as necessary for construction operations.

1. Coordinate elevations of temporary roads and paved areas with permanent roads and paved areas.
2. Prepare subgrade and install subbase and base for temporary roads and paved areas according to Division 31 Section "Earth Moving."

3. Recondition base after temporary use, including removing contaminated material, regrading, proofrolling, compacting, and testing.
 4. Delay installation of final course of permanent hot-mix asphalt pavement until immediately before Substantial Completion. Repair hot-mix asphalt base-course pavement before installation of final course according to Division 32 Section "Rigid Paving."
- D. Traffic Controls: Comply with requirements of authorities having jurisdiction.
1. Protect existing site improvements to remain including curbs, pavement, and utilities.
 2. Maintain access for fire-fighting equipment and access to fire hydrants.
 1. Unless described and approved under a Traffic Control Plan (TCP), conduct operations on the site so that the use of any plant roads by vehicles employed under this Contract will not restrict pedestrian and vehicular traffic thereon nor hinder the use of such facilities.
 2. All roads within the plant are used simultaneously by vehicles and pedestrians. The speed limit of 15 mph (20km/h) applies throughout the plant, including the access roads and parking lots. Failure to comply with speed limit or to operate vehicles safely will result in possible removal of the staff from the plant.
- E. Parking: Provide temporary parking areas for construction personnel. The Contractor shall not use public roads or undesignated areas for parking.
- F. Dewatering Facilities and Drains: Comply with requirements of authorities having jurisdiction. Maintain Project site, excavations, and construction free of water.
1. Dispose of rainwater in a lawful manner that will not result in flooding Project or adjoining properties or endanger permanent Work or temporary facilities.
 2. Remove snow and ice as required to minimize accumulations.
- G. Project Signs: Provide Project signs in accordance with Contract Documents. Unauthorized signs are not permitted.
1. Identification Signs: Provide Project identification signs as indicated on Drawings.
 2. Temporary Signs: Provide other signs as required to inform public and individuals seeking entrance to Project.
 - a. Provide temporary, directional signs for construction personnel and visitors.
 3. Maintain and touchup signs so they are legible at all times.

- H. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction. (NTS: Retain "Lifts and Hoists" Paragraph below for construction of more than two stories.)
 - I. Lifts and Hoists: Provide facilities necessary for hoisting materials and personnel.
 - 1. Truck cranes and similar devices used for hoisting materials are considered "tools and equipment" and not temporary facilities.
 - J. Temporary Stairs: Until permanent stairs are available, provide temporary stairs where ladders are not adequate.
 - K. Temporary Use of Permanent Stairs: Use of new stairs for construction traffic will be permitted, provided stairs are protected and finishes restored to new condition at time of Substantial Completion.
- 3.04 SECURITY AND PROTECTION FACILITIES INSTALLATION:
- A. Protection of Existing Facilities: Protect existing vegetation, equipment, structures, utilities, and other improvements at Project site and on adjacent properties, except those indicated to be removed or altered. Repair damage to existing facilities.
 - B. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction to comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.
 - 1. Comply with work restrictions specified in Division 01 Section "Summary of Work."
 - C. Temporary Erosion and Sedimentation Control: Comply with requirements specified in Section 01 57 13 Erosion Control, Sedimentation and Containment of Construction Material.
 - D. Stormwater Control: Comply with requirements of authorities having jurisdiction. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of stormwater from heavy rains.
 - E. Tree and Plant Protection: Install temporary fencing located as indicated or outside the drip line of trees to protect vegetation from damage from construction operations. Protect tree root systems from damage, flooding, and erosion.
 - F. Pest Control: Engage pest-control service to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Substantial Completion. Perform control operations lawfully, using environmentally safe materials.

- G. Site Enclosure Fence: Prior to commencing earthwork, furnish and install site enclosure fence in a manner that will prevent people and animals from easily entering site except by entrance gates. The Owner shall not assume liability for breaches of security on the Contractor's Work Area. It is the Contractor's responsibility to secure its construction materials, tools and equipment. The Owner is not responsible for providing security services, and is not responsible for any loss, theft or damage to any equipment/material within the Contractor's Work Area
1. Extent of Fence: As required to enclose entire Project site or portion determined sufficient to accommodate construction operations
 2. Maintain security by limiting number of keys and restricting distribution to authorized personnel. Furnish one set of keys to Owner.
- H. Security Enclosure and Lockup: Install temporary enclosure around partially completed areas of construction. Provide lockable entrances to prevent unauthorized entrance, vandalism, theft, and similar violations of security. Lock entrances at end of each work day.
- I. Barricades, Warning Signs, and Lights: Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.
- J. Temporary Egress: Maintain temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction.
- K. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. Provide temporary weathertight enclosure for building exterior.
1. Where heating or cooling is needed and permanent enclosure is incomplete, insulate temporary enclosures.
- L. Temporary Fire Protection: Install and maintain temporary fire-protection facilities of types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 241; manage fire-prevention program.
1. Prohibit smoking in construction areas.
 2. Supervise welding operations, combustion-type temporary heating units, and similar sources of fire ignition according to requirements of authorities having jurisdiction.
 3. Develop and supervise an overall fire-prevention and -protection program for personnel at Project site. Review needs with local fire department and establish procedures to be followed. Instruct personnel in methods and procedures. Post warnings and information.

4. Provide temporary standpipes and hoses for fire protection. Hang hoses with a warning sign stating that hoses are for fire-protection purposes only and are not to be removed. Match hose size with outlet size and equip with suitable nozzles.

3.05 MOISTURE AND MOLD CONTROL:

- A. Contractor's Moisture-Protection Plan: Avoid trapping water in finished work. Document visible signs of mold that may appear during construction.
- B. Exposed Construction Phase: Before installation of weather barriers, when materials are subject to wetting and exposure and to airborne mold spores, protect as follows:
 1. Protect porous materials from water damage.
 2. Protect stored and installed material from flowing or standing water.
 3. Keep porous and organic materials from coming into prolonged contact with concrete.
 4. Remove standing water from decks.
 5. Keep deck openings covered or dammed.
- C. Partially Enclosed Construction Phase: After installation of weather barriers but before full enclosure and conditioning of building, when installed materials are still subject to infiltration of moisture and ambient mold spores, protect as follows:
 1. Do not load or install drywall or other porous materials or components, or items with high organic content, into partially enclosed building.
 2. Keep interior spaces reasonably clean and protected from water damage.
 3. Periodically collect and remove waste containing cellulose or other organic matter.
 4. Discard or replace water-damaged material.
 5. Do not install material that is wet.
 6. Discard, replace, or clean stored or installed material that begins to grow mold.
 7. Perform work in a sequence that allows any wet materials adequate time to dry before enclosing the material in drywall or other interior finishes.
- D. Controlled Construction Phase of Construction: After completing and sealing of the building enclosure but prior to the full operation of permanent HVAC systems, maintain as follows:
 1. Control moisture and humidity inside building by maintaining effective dry-in conditions.

2. Use permanent HVAC system to control humidity.
3. Comply with manufacturer's written instructions for temperature, relative humidity, and exposure to water limits.
 - a. Hygroscopic materials that may support mold growth, including wood and gypsum-based products, that become wet during the course of construction and remain wet for 48 hours are considered defective.
 - b. Measure moisture content of materials that have been exposed to moisture during construction operations or after installation. Record readings beginning at time of exposure and continuing daily for 48 hours. Identify materials containing moisture levels higher than allowed. Report findings in writing to Engineer.
 - c. Remove materials that cannot be completely restored to their manufactured moisture level within 48 hours.

3.06 CLEANING ENGINEER'S AND CONSTRUCTION OFFICES DURING CONSTRUCTION:

- A. Contractor to maintain the grounds within his working limits and around any equipment or storage areas. This includes removal of waste material, cutting of grass, weed whacking around storage racks and material, snow plowing and snow shoveling.
- B. The Contractor shall make arrangements with, and obtain permits from, any authorities having jurisdiction for disposal of waste and debris.
- C. The Contractor shall wet down exterior surfaces prior to sweeping to prevent blowing of dust and debris. At least weekly, the Contractor shall sweep all floors (basins, tunnels, platforms, walkways, roof surfaces), and pick up all debris and dispose of off Site.
- D. The Contractor shall provide approved containers for collection and disposal of waste materials, debris, and rubbish. At least at weekly intervals, the Contractor shall dispose of such waste materials, debris, and rubbish off Site.
- E. At least weekly, the Contractor shall brush sweep entry drive and roadways, and all other streets and walkways affected by the Work and where adjacent to the Work.

3.07 OFFICE FOR ENGINEER:

- A. Locate the Engineer's Field inside the field office.
- B. Communication Services: The Contractor shall arrange and provide on Site telephone service and cable Internet access including router/firewall for use during construction. The Contractor shall pay for all installation and basic monthly billing charges. The Contractor shall reinstate service outages resulting from construction activities within one Working Day.

- C. Maintain all temporary buildings clean and free from nuisances so as to avoid danger to plant property or structures, and to prevent complaints from plant personnel, and prohibit interferences with the operation of the existing plant.
 - D. Maintain in good repair and appearance, and provide daily cleaning service and replenishment, as required, of paper towels, paper cups, hand soap, toilet paper, first-aid kit supplies, and bottled water.
 - E. Provide and maintain services including power, heating and ventilating.
- 3.08 OPERATION, TERMINATION, AND REMOVAL:
- A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.
 - B. Maintenance: Maintain facilities in good operating condition until removal.
 - 1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.
 - C. Operate Project-identification-sign lighting daily from dusk until 12:00 midnight unless directed otherwise by Owner.
 - D. Temporary Facility Changeover: Do not change over from using temporary security and protection facilities to permanent facilities until Substantial Completion.
 - E. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.
 - 1. Materials and facilities that constitute temporary facilities are property of Contractor. Owner reserves right to take possession of Project identification signs.
 - 2. Remove temporary roads and paved areas not intended for or acceptable for integration into permanent construction. Where area is intended for landscape development, remove soil and aggregate fill that do not comply with requirements for fill or subsoil. Remove materials contaminated with road oil, asphalt and other petrochemical compounds, and other substances that might impair growth of plant materials or lawns. Repair or replace street paving, curbs, and sidewalks at temporary entrances, as required by authorities having jurisdiction.
 - 3. At Substantial Completion, repair, renovate, and clean permanent facilities used during construction period. Comply with final cleaning requirements specified in Division 01 Section "Contract Closeout."

END OF SECTION

SECTION 01 57 13

EROSION CONTROL, SEDIMENTATION AND CONTAINMENT OF CONSTRUCTION MATERIALS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide all work and take all measures necessary to control soil erosion resulting from construction operations, prevent flow of sediment from construction site, and contain construction materials (including excavation and backfill) within protected working area as to prevent damage to any stream or wetlands as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. Owner's environmental management plans and associated environmental protection plans
- B. United States Environmental Protection Agency (USEPA):
 - 1. Guidelines for Erosion and Sediment Control, Planning and Implementation.
 - 2. Processes, Procedures and Methods to Control Pollution Resulting from all Construction Activity.
- C. City of Provo Public Works
- D. Utah Department of Environmental Quality

1.03 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
- B. Two weeks prior to the start of the work, submit to Engineer, for review, a plan with detailed sketches showing the proposed methods to be used for controlling erosion during construction.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Use acceptable procedures, including use of water diversion structures, diversion ditches, settling basins, and sediment traps.
- C. Operations restricted to areas of work indicated on drawings and area which must be entered for construction of temporary or permanent facilities.

- D. If construction materials are washed away during construction, remove materials from fouled areas.
- E. Stabilize diversion outlets by means acceptable to Engineer.
- F. Engineer has authority to limit surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations and to direct immediate permanent or temporary pollution control measures to prevent contamination of any stream or wetlands, including construction of temporary berms, dikes, dams, sediment basins, sediment traps, slope drains, and use of temporary mulches, mats, or other control devices or methods to control erosion.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Provide materials in accordance with EPA Stormwater Pollution Prevention

PART 3 - EXECUTION

3.01 GENERAL:

- A. Do not discharge chemicals, fuels, lubricants, bitumen, raw sewage and other harmful waste into or alongside any body of water or into natural or man-made channels.
- B. Design erosion and sediment controls to handle peak runoff resulting from storm events.
- C. The Contractor shall be responsible for inspecting and maintaining these control measures to ensure their proper function and adequate sediment storage at all times. The Contractor shall remove sediment once it reaches 50 percent of the capacity of the structure. Sediment collected shall be disposed of offsite at the Contractor's cost.

3.02 INSTALLATION:

- A. Install baled hay or straw erosion checks in all locations as directed, surrounding base of all deposits of stored excavated material outside of disturbed area, and where directed by the Engineer.
- B. Install checks immediately after site is cleared and before trench excavation. Locate checks, surrounding stored material, approximately 6 feet from material.
- C. Hold bales in place with two 2 inches by 2 inches by 3 feet stakes so that each bale is butted tightly against adjoining bale thereby precluding shortcircuiting of erosion check.
- D. Construct earth berms or diversions to intercept and divert runoff water from critical areas.

- E. Discharge silt-laden water from excavations onto filter fabric mat and/or baled hay or straw sediment traps to ensure that only sediment-free water is returned to watercourses.
- F. Do not place excavated soil material adjacent to water-course in manner that will cause it to wash away by high water or runoff.
- G. Prevent damage to vegetation by excessive watering or silt accumulation in the discharge area.
- H. Do not dump spoiled material into any streams, wetlands, surface waters, or unspecified locations.
- I. Prevent indiscriminate, arbitrary, or capricious operation of equipment in streams, wetlands or surface waters.
- J. Do not pump silt-laden water from trenches or excavations into surface waters, streams, wetlands, or natural or man-made channels leading thereto.
- K. Prevent damage to vegetation adjacent to or outside of construction area limits.
- L. Do not dispose of trees, brush, debris, paints, chemicals, asphalt products, concrete curing compounds, fuels, lubricants, insecticides, washwater from concrete trucks or hydroseeders, or any other pollutant in streams, wet-lands, surface waters, or natural or man-made channels leading thereto, or unspecified locations.
- M. Do not alter flow line of any stream unless indicated or specified.

END OF SECTION

SECTION 01 61 00
CONTROL OF MATERIALS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; and comparable products.

1. Section Includes:

- a. Definitions
- b. Spare parts
- c. Quality assurance
- d. Delivery, storage and handling
- e. Products
- f. Acceptance of materials
- g. Reuse of existing material
- h. Manufacturer's instructions
- i. Special tools
- j. Lubrication
- k. Nameplates
- l. Loads and seismic forces
- m. General material and equipment requirements
- n. Materials and Equipment
- o. Field Quality Control; Installation, Instructional, and Post Startup Services

1.02 DEFINITIONS:

- A. Products: Items obtained for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.
 - 1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature, that is current as of date of the Contract Documents.
 - 2. New Products: Items that have not previously been incorporated into another project or facility. Products salvaged or recycled from other projects are not considered new products.
 - 3. Comparable Product: Product that is demonstrated and accepted through submittal process to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.

1.03 SPARE PARTS:

- A. Provide spare parts for Products as specified in the individual technical specification sections. Comply with the requirements specified in Section 01 61 00.
- B. Pack spare parts to protect them during storage. Tag spare parts and containers to clearly identify them in accordance with Owners' parts numbering system as reviewed by the Engineer. All parts shall be cross-referenced to their applicable Specification Section.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 61 00.
- B. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, select product compatible with products previously selected, even if previously selected products were also options.

1.05 DELIVERY STORAGE AND HANDLING:

- A. Contractor shall arrange deliveries of materials and equipment in accordance with construction Progress Schedule, coordinate to avoid conflict with Work and conditions at site.
- B. Comply with the requirements of Section 01 66 00.
- C. Provide equipment and personnel to handle materials and equipment by methods recommended by manufacturer to prevent soiling or damage to materials or equipment, or their packaging.

- D. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.
- E. Owner assumes no responsibility for damage or loss due to storage of materials and equipment.
- F. Interior Storage:
 - 1. Store with seals and labels intact and legible.
 - 2. Store materials and equipment subject to damage by elements in weathertight enclosures.
 - 3. Maintain temperature and humidity within ranges required by manufacturer's instructions.
- G. Exterior Storage:
 - 1. Store fabricated materials and equipment above ground, on blocking or skids, to prevent soiling or staining. Cover materials and equipment subject to deterioration with impervious sheet coverings. Provide ventilation to avoid condensation.
 - 2. Store loose granular materials in well-drained area on solid surfaces to prevent mixing with foreign matter.
 - 3. Store materials such as pipe, reinforcing steel, structural steel, and equipment on pallets or racks, off ground.
- H. Inspection and Maintenance:
 - 1. Arrange storage to provide easy access for inspection, maintenance, and inventory.
 - 2. Make periodic inspections of stored materials and equipment to ensure materials and equipment maintained under specified conditions are free from damage or deterioration, and coverings are in-place and in condition to provide required protection.
 - 3. Perform maintenance on stored material and equipment in accordance with manufacturer's written instructions and in presence of Owner or Engineer.
 - a. Notify Engineer 24 hours before performance of maintenance.
 - b. Submit report of completed maintenance and condition of coverings to Engineer with each Application for Payment.
 - c. Failure to perform maintenance, to notify Engineer of intent to perform maintenance or to submit maintenance report may result in rejection of material or equipment.

- I. Contractor assumes responsibility for protection of completed construction and repair and restore damage to completed Work equal to original condition until acceptance and closeout of project by Owner subject to warranty requirements.
- J. Wheeling of loads over finished floors, with or without plank protection, is not permitted in anything except rubber-tired wheelbarrows, buggies, trucks or dollies. This applies to finished floors and exposed concrete floors, as well as those covered with composition tile or other applied surfacing.
- K. Where structural concrete is also finished surface, avoid marking or damaging surface.

1.06 PRODUCTS:

- A. Furnish products of qualified manufacturers suitable for intended use. Furnish products of each type by single manufacturer unless specified otherwise.
- B. Do not use materials and equipment removed from existing premises, except as specifically permitted by Contract Documents.
- C. Furnish interchangeable components from same manufacturer for components being replaced.

1.07 ACCEPTANCE OF MATERIALS:

- A. Unless otherwise specified, only new materials and equipment shall be incorporated in the work. All materials and equipment furnished by the Contractor shall be subject to the inspection and acceptance of the Engineer. No material shall be delivered to the work without prior acceptance of the Engineer.
- B. As specified in Section 01 33 00, the Contractor shall submit to the Engineer, data relating to materials and equipment he proposes to furnish for the work. Such data shall be in sufficient detail to enable the Engineer to identify the particular product and to form an opinion as to its conformity to the specifications.
- C. Facilities and labor for handling and inspection of all materials and equipment shall be furnished by the Contractor. If the Engineer requires, either prior to beginning or during the progress of the work, the Contractor shall submit additional samples or materials for such special tests as may be necessary to demonstrate that they conform to the specifications. Such samples shall be furnished, stored, packed, and shipped at the Contractor's expense. Except as otherwise noted, the Owner will make arrangements for and pay for the tests.
- D. Any delay of acceptance resulting from the Contractor's failure to submit samples or data promptly shall not be used as a basis of a claim against the Owner or the Engineer.
- E. In order to demonstrate the proficiency of workmen or to facilitate the choice among several textures, types, finishes, and surfaces, the Contractor shall provide such samples of workmanship or finish as may be required.

- F. The materials and equipment used on the work shall correspond to the accepted samples or other data.

1.08 REUSE OF EXISTING MATERIAL:

- A. Except as specifically indicated or specified, do not use materials and equipment removed from existing structure(s) in new Work.

1.09 MANUFACTURER'S INSTRUCTIONS:

- A. Installation of equipment and materials shall comply with manufacturer's instructions. Obtain and distribute printed copies of such instructions to parties involved in installation, including one copy to Engineer.

- 1. Maintain one set of complete instructions at Site during installation and until completion of Work.

- B. Handle, store, install, connect, clean, condition, and adjust materials and equipment in accordance with manufacturer's written instructions and in conformance with Specifications.

- 1. If Site conditions or specified requirements conflict with manufacturer's instructions, Engineer for further instructions. Do not proceed with Work without written instructions.

1.10 SPECIAL TOOLS:

- A. For each type of equipment furnished, the Contractor shall provide a complete set of all special tools (including grease guns or other lubricating devices) which may be necessary for the adjustment, operation, maintenance, and disassembly of such equipment. Tools shall be high-grade, smooth, forged, alloy, tool steel. Grease guns shall be lever type.

- B. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment.

- C. Pack items to protect them during storage. Tag items and containers to clearly identify them in accordance with Owner's part system, as reviewed by the Engineer. Cross-reference all items to their applicable Specification Section.

- D. Special tools shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such special tools until completion of the work, at which time they shall be delivered to the Owner.

- E. The Contractor shall furnish and erect one or more steel wall cases with flat key locks and clips or hooks to hold each tool in arrangement.

1.11 LUBRICATION:

- A. Where lubrication is required for proper operation of equipment, incorporate necessary and proper provisions in equipment in accordance with manufacturer's requirements. Where possible, lubrication shall be automated and positive.
- B. Where oil is used, reservoir shall be of sufficient capacity to supply unit for 48-hour period.
- C. Provide adequate and, as far as practicable, automatic means of lubrication for working parts. Arrange lubrication grease nipples, grease boxes and other lubrication devices so that they are readily accessible for routing greasing using grease nipples and Type 316 stainless steel or copper tubing extensions where required. Secure nipples and tubing to the equipment at appropriate locations. Indicate on the working drawings submitted, the types of lubricants to be used (must be readily available in the State of Utah). Use grease nipples of a consistent type, Alemite button head type or equivalent. Provide grease gun(s) of the appropriate size(s) and pressure(s).
- D. Provide a one (1) year supply of all lubricants necessary for the routine, daily operation of the equipment. All lubricants to be readily available in the State of Utah. Provide a complete schedule of all the lubricant including the manufacturer name, type, name and local address and phone number of where each lubricant can be purchased for each piece of equipment.

1.12 NAMEPLATES:

- A. With the exceptions mentioned below, each piece of equipment shall be provided with a nameplate of non-corrodible metal, securely fastened in place and clearly and permanently inscribed with the manufacturer's name, model or type designation, serial number, principal rated capacities, electrical or other power characteristics, and similar information.
- B. This requirement shall not apply to standard, manually operated hydrants or to gate, globe check and plug valves.
- C. Each process valve shall be provided with a substantial tag of non-corrodible metal securely fastened in place and inscribed with an identification number in conformance with the Valve Identification Schedule indicated on the drawings or furnished by the Engineer.

1.13 LOADS AND SEISMIC FORCES:

- A. See Section 01 41 20.
- B. Provide anchorage and supports for products, including equipment, assemblies, and pipe, designed to resist the following loads and seismic forces.
 - 1. Horizontal forces: 100 percent of dead and live loads acting in any direction in the horizontal plane applied to the center of gravity of the load.
 - 2. Vertical forces: 50 percent of the dead and live load, acting either upward or downward applied at the center of gravity of the load.
 - 3. Cantilevered anchorages/supports: 100 percent of the dead and live loads acting in any direction applied at the center of gravity of the load.
- C. Seismic and wind force determination: in accordance with Section 01 41 20.
- D. Products, including equipment and assemblies, in normal submerged condition operation: analysis of seismic forces in both submerged/dry condition in accordance with loading per Section 01 41 20.
- E. Above ground tanks, their supports and anchorages: Design fabricate and install to comply with the seismic requirements of applicable codes and in accordance with Section 01 41 20.
- F. Analysis of loads and seismic force: Performed by a registered Engineer in the state of Utah with experience in this type of work.
- G. Furnish copies of analysis with submittals for equipment, assemblies, and pipe.

1.14 GENERAL MATERIAL AND EQUIPMENT REQUIREMENTS:

- A. The requirements of this Paragraph shall constitute the standards for the material and equipment specified herein. Should these requirements conflict with the Supplier's recommendations or in any way be less stringent than the Supplier's requirements, they shall be superseded by the Supplier's requirements.
- B. Bolts, Anchor Rods and Nuts:
 - 1. All necessary bolts, anchor rods, nuts, washers, plates and bolt sleeves shall be furnished by the Contractor in accordance herewith. Anchor rods shall have suitable washers and hexagonal nuts.
 - 2. All anchor rods, nuts, washers, plates, and bolt sleeves shall be stainless steel unless otherwise indicated or specified.
 - 3. Unless otherwise specified, stud, tap, and machine bolts, and nuts shall conform to the requirements of ASTM Standard Specification for High Strength Structural

Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, Designation F3125. Hexagonal nuts of the same quality of metal as the bolts shall be used. All threads shall be clean cut and shall conform to ANSI Standard B1.1 for Unified Inch Screw Threads (UN and UNR Thread Form).

4. Bolts, anchor rods, nuts, and washers, specified to be galvanized, shall be zinc coated, after being threaded, by the hot-dip process in conformity with the ASTM Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip, Designation A123, or the ASTM Standard Specifications for Zinc Coating (Hot Dip) on Iron and Steel Hardware, Designation A153, as is appropriate.
5. Bolts, anchor rods, nuts, and washers specified to be stainless steel shall be Type 304 or Type 316 stainless steel, as indicated.
6. Anchor rods shall be set accurately. They shall be carefully held in suitable templates of acceptable design. Where indicated on the Drawings, specified, or required, anchor bolts shall be provided with square plates at least 4 inches by 4 inches by 3/8 inch or shall have square heads and washers and set in the concrete forms with suitable pipe sleeves, or both. If anchors are set after the concrete has been placed, all necessary drilling and grouting or caulking shall be done by the Contractor and care shall be taken not to damage the structure or finish by cracking, chipping, spalling, or otherwise during the drilling and caulking.

C. Grease Fittings:

1. Provide extension fittings and tubing on all grease fittings that are installed in an inaccessible location. The extension is to be located so that equipment can be lubricated from the operating level without the use of ladders, staging or shutting down the equipment. Tubing: 316 stainless steel.

D. Equipment Foundations, Installation and Grouting:

1. The Contractor shall furnish the necessary materials and construct suitable concrete foundations for all equipment installed by him, even though such foundations may not be indicated on the Drawings. The tops of foundations shall be at such elevations as will permit grouting as specified below.
2. All such equipment shall be installed by skilled mechanics and in accordance with the instructions of the manufacturer.
3. In setting pumps, motors, and other items of equipment customarily grouted, the Contractor shall make an allowance of at least 1 inch for grout under the equipment bases. Shims used to level and adjust the bases shall be steel. Shims may be left embedded in the grout, in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work. Unless otherwise permitted, all grout shall be a suitable non-metallic, non-shrink grout.

4. Grout shall be mixed and placed in accordance with the recommendations of the manufacturer. Where practicable, the grout shall be placed through the grout holes in the base and worked outward and under the edges of the base and across the rough top of the concrete foundation to a peripheral form so constructed as to provide a suitable chamfer around the top edge of the finished foundation.
5. Where such procedure is impracticable, the method of placing grout shall be as accepted by the Engineer. After the grout has hardened sufficiently, all forms, hoppers, and excess grout shall be removed, and all exposed grout surfaces shall be patched in an accepted manner and given a burlap-rubbed finish.

E. Equipment Drive Guards:

1. All equipment driven by open shafts, belts, chains, or gears shall be provided with acceptable all-metal guards enclosing the drive mechanism. Guards shall be constructed of galvanized sheet steel (12 gage minimum) or galvanized woven wire or expanded metal set in a frame of galvanized steel members. Guards shall be secured in position by steel braces or straps which will permit easy removal for servicing the equipment. The guards shall conform in all respects to all applicable safety codes and regulations.
2. Provide pivoting access covers for shaft speed measurements.

F. Protection Against Electrolysis:

1. Where dissimilar metals are used in conjunction with each other, provide insulation between adjoining surfaces to eliminate direct contact and any resultant electrolysis. Provide bituminous insulation, heavy bituminous coatings, nonmetallic separators or washers, impregnated felt, or other means to provide insulation.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT:

A. Material and Equipment Incorporated into Work:

1. Conform to applicable specifications and standards.
2. Comply with size, make, type, and quality specified or as accepted by Submittal.

B. Manufactured and Fabricated Materials and Equipment:

1. Design, fabricate, and assemble in accordance with engineering and shop practices standard with industry.

2. Manufacture like parts of duplicate units to standard sizes and gauges, to be interchangeable.
 3. Two or more items of same kind shall be identical, by same manufacturer.
 4. Material and equipment shall be suitable for service conditions.
 5. Equipment capabilities, sizes, and dimensions shown or specified shall be adhered to, unless variations are specifically accepted, in writing.
 6. Equipment shall be adapted to best economy in power consumption and maintenance. Parts and components shall be proportioned for stresses occurring during continuous or intermittent operation, and for additional stresses occurring during fabrication or installation.
 7. Design so working parts are readily accessible for inspection and repair, easily duplicated, and replaced.
 8. Design structural members of equipment for anticipated shock and vibratory loads.
 9. Design machinery such that working parts are readily accessible for inspection and repair, and that each part is suitable for the service required.
- C. Do not use material or equipment for purpose other than for which it is designed or specified.

PART 3 - EXECUTION

- 3.01 FIELD QUALITY CONTROL; INSTALLATION, INSTRUCTIONAL, AND POST STARTUP SERVICES:
- A. General: Provide services in accordance with Section 01 78 25.
 - B. Training: Comply with Section 01 78 25.
- 3.02 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 01 66 10

DELIVERY, STORAGE AND HANDLING

PART 1 - GENERAL

1.01 GENERAL:

- A. This Section specifies the general requirements for the delivery handling, storage and protection for all items required in the construction of the work as indicated and in compliance with Contract Documents. Specific requirements, if any, are specified with the related item.

1.02 TRANSPORTATION AND DELIVERY:

- A. Transport and handle items in accordance with manufacturer's printed instructions.
- B. Before shipping to the Site, contact the Engineer, in writing, giving at least fourteen (14) Days prior notice to enable the Engineer or its authorized inspector to inspect the equipment if necessary. Assemble the complete unit in the factory for inspection by the Engineer or its authorized inspector. Do not ship the equipment until the Engineer has completed its inspection.
- C. Schedule delivery to reduce long term on-site storage prior to installation and/or operation. Under no circumstances shall equipment be delivered to the site more than one month prior to installation without written authorization from the Engineer.
- D. Ship equipment, material and spare parts complete except where partial disassembly is required by transportation regulations or for protection of components.
- E. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended. All spare parts shall be cross-referenced to their applicable the Specification Section.
- F. Carefully pack and crate equipment for shipment. Protect polished and machined metal surfaces from corrosion and damage during shipment and installation. Specially pack electrical equipment to prevent damage by moisture. Cover equipment having exposed bearings and glands to exclude foreign matter. Carefully pack machines for shipment and protect electrical equipment from moisture damage. Protect bearings, seals and glands from grit and dirt.
- G. Identify each component with durable identifying labels or tags securely attached to each piece of equipment, crate or container.
- H. Finished surfaces of all exposed flanges shall be protected by fiberboard blank flanges strongly built and securely bolted thereto.

- I. Deliver spare parts at same time as pertaining equipment. Deliver spare parts to owner after completion of work.
- J. Coordinate delivery with installation to ensure minimum holding time for items that are hazardous, flammable, easily damaged or sensitive to deterioration.
- K. Deliver products to the site in manufacturer's original sealed containers or other packing systems, complete with instructions for handling, storing, unpacking, protecting and installing.
- L. Assume responsibility for equipment material and spare parts just before unloading from carrier at site.
- M. All items delivered to the site shall be unloaded and placed in a manner which will not hamper the Contractor's normal construction operation or those of subcontractors and other contractors and will not interfere with the flow of necessary traffic.
- N. Provide equipment and personnel to unload all items delivered to the site..
- O. Promptly inspect shipment to assure that products comply with requirements, quantities are correct, and items are undamaged. For items furnished by others (i.e. Owner, other Contractors), perform inspection in the presence of the Engineer. Notify Engineer verbally, and in writing, of any problems.
- P. Pay all demurrage charges if failed to promptly unload items.

1.03 STORAGE AND PROTECTION:

- A. Store and protect products and equipment in accordance with the manufacturer's instructions, with seals and labels intact and legible. Storage instruction shall be studied by the Contractor and reviewed with the Engineer by him. Instructions shall be carefully followed and a written record of this kept by the Contractor for each product and pieces of equipment.
- B. Arrange storage of products and equipment to permit access for inspection. Periodically inspect to make sure products and equipment are undamaged and are maintained under specified conditions.
- C. Provide protective maintenance during storage consisting of manually exercising equipment, inspecting mechanical surfaces for signs or corrosion or other damage, lubricating, applying any coatings as recommended by the equipment manufacturer necessary for its protection and all other precautions to assure proper protection of all equipment stored and for compliance with manufacturers' requirements related to warranties. Log all protective maintenance for each piece of equipment in the written record noted above.
- D. Store loose granular materials on solid flat surface in a well-drained area. Prevent mixing with foreign matter.

- E. Cement and lime shall be stored under a roof and off the ground and shall be kept completely dry at all times. All structural, miscellaneous and reinforcing steel shall be stored off the ground or otherwise to prevent accumulation of dirt or grease, and in a position to prevent accumulations of standing water and to minimize rusting. Beams shall be stored with the webs vertical. Precast concrete shall be handled and stored in a manner to prevent accumulations of dirt, standing water, staining, chipping or cracking. Brick, block and similar masonry products shall be handled and stored in manner to reduce breakage, cracking and spalling to a minimum.
- F. All mechanical and electrical equipment and instruments shall be covered with canvas and stored in a weathertight building to prevent injury. The building may be a temporary structure on the site or elsewhere, but it shall be satisfactory to the Engineer. Building shall be provided with adequate ventilation to prevent condensation. Maintain temperature and humidity within range required by manufacturer and to prevent condensation on the equipment being stored.
1. All equipment shall be stored fully lubricated with oil, grease and other lubricants unless otherwise instructed by the manufacturer.
 2. Moving parts shall be rotated a minimum of once weekly to insure proper lubrication and to avoid metal-to-metal "welding". Log all rotation maintenance for each piece of equipment in the written record noted above.
 3. Upon installation of the equipment, the Contractor shall start the equipment, at least half load, once weekly for an adequate period of time to ensure that the equipment does not deteriorate from lack of use. Log all startup for each piece of equipment in the written record noted above.
 4. Lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment at the time of acceptance.
 5. Prior to acceptance of the equipment, the Contractor shall have the manufacturer inspect the equipment and certify that its condition has not been detrimentally affected by the long storage period. Such certifications by the manufacturer shall be deemed to mean that the equipment is judged by the manufacturer to be in a condition equal to that of equipment that has been shipped, installed, tested and accepted in a minimum time period. As such, the manufacturer will guaranty the equipment equally in both instances. If such a certification is not given, the equipment shall be judged to be defective. It shall be removed and replaced at the Contractor's expense.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01 71 13

MOBILIZATION

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section is provided to cover Contractor's cost of general and miscellaneous responsibilities and operations not normally attributed to, or included in, any other single bid item. This shall include, but not necessarily be limited to, work described or enumerated in this section under the following subsections.

1.02 MOVING TO AND FROM THE JOB SITE

- A. This shall include Contractor's preliminary arrangement for starting and stopping construction operations, work schedules, and transportation of equipment and personnel to and from the project.

1.03 CLEAN-UP

- A. The cost of all clean-up work as specified and not covered under other items shall be included in the Bid. Values shall be included in the Bid Schedule, lump-sum price, for "Mobilization/Demobilization".

1.04 TEMPORARY UTILITIES

- A. The cost of water, power, etc. required by Contractor in performing the Work specified in the Contract shall be included in the Bid. Values shall be included in the Bid Schedule, lump-sum price, for "Mobilization/Demobilization".

1.05 PERFORMANCE BOND, PAYMENT BOND, AND INSURANCE

- A. The cost of the Performance Bond, Payment Bond, and any required insurance and/or other miscellaneous cost associated with this Project shall be included with the Bid. Values shall be included in the Bid Schedule, lump-sum price, for "Mobilization/Demobilization".

1.06 PERMITS

- A. Contractor shall provide all necessary permits for completion of the Work. Values shall be included in the Bid Schedule, lump-sum price, for "Mobilization/ Demobilization".

1.07 PRE-CONSTRUCTION VIDEO RECORDS

- A. Contractor is required to produce a preconstruction video recording of areas where Work is to be performed. The video record shall be of professional quality and the coverage shall be such, as to allow accurate determination of location, size, and conditions, etc. of

existing features and improvements within the rights-of-way. Contractor shall provide Owner with a copy of the rights-of-way video in electronic format on a digital video disc (DVD) or solid-state drive (USB or Thumb Drive) before construction begins.

1.08 PROJECT SIGN

- A. The cost of furnishing and installing a project sign per the Section 01 50 00 and in accordance with the Bidding Requirements shall be included in the Bid Schedule, lump-sum price, for "Mobilization". The project sign shall be installed at the Primary Entrance to the Construction Site.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01 74 23

CLEANING UP

PART 1 - GENERAL

1.01 SUMMARY:

- A. Execute cleaning during progress of Work and at completion of Work as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. Refer to specification sections for specific cleaning for Products or Work.
- B. American Water Works Association (AWWA)

- 1. C652: Disinfection of Water Storage Facilities

1.03 DISPOSAL REQUIREMENTS:

- A. Conduct cleaning and disposal operations to comply with local codes, ordinances, regulations, and anti-pollution laws. Do not burn or bury rubbish or waste materials on Project site. Do not dispose of volatile wastes, such as mineral spirits, oil, or paint thinner, in storm or sanitary drains. Do not dispose of wastes into streams or waterways.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Use only those cleaning materials which will not create hazards to property and persons or damage surfaces of material to be cleaned.
- B. Use only cleaning materials recommended by manufacturer of surface to be cleaned.

PART 3 - EXECUTION

3.01 CLEANING DURING CONSTRUCTION:

- A. At all times maintain areas covered by the contract and adjacent properties and public access roads free from accumulations of waste, debris, and rubbish caused by construction operations.
- A. During execution of work, clean site, adjacent properties, and public access roads and dispose of waste materials, debris, and rubbish to assure that buildings, grounds, and public properties are maintained free from accumulations of waste materials and rubbish.

Unneeded construction equipment shall be removed and all damage repaired so that the public and property owners will be inconvenienced as little as possible.

- B. Wet down dry materials and rubbish to lay dust and prevent blowing dust.
- C. Cover or wet excavated material leaving and arriving at the site to prevent blowing dust. Clean the public access roads to the site of any material falling from the haul trucks.
- D. Where material or debris has washed or flowed into or been placed in existing watercourses, ditches, gutters, drains, pipes structures, work done under this contract, or elsewhere during the course of the Contractor's operations, such material or debris shall be entirely removed and satisfactorily disposed of during the progress of the work, and the ditches, channels, drains, pipes, structures, and work, etc., shall, upon completion of the work, be left in a clean and neat condition.
- E. On or before the completion of the work, the Contractor shall, unless otherwise especially directed or permitted in writing, tear down and remove all temporary buildings and structures built by him; shall remove all temporary works, tools, and machinery or other construction equipment furnished by him; shall remove, acceptably disinfect, and cover all organic matter and material containing organic matter in, under, and around privies, houses, and other buildings used by him; shall remove all rubbish from any grounds which he has occupied; and shall leave the roads and all parts of the premises and adjacent property affected by his operations in a neat and satisfactory condition.
- F. Provide on-site containers for collection and removal of waste materials, debris, and rubbish in accordance with applicable regulations.

3.02 FINAL CLEANING:

- A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.
- B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
 - 1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:
 - a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
 - b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.

- c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
- d. Remove tools, construction equipment, machinery, and surplus material from Project site.
- e. Remove snow and ice to provide safe access to building.
- f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, construction dust, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
- g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
- h. Sweep concrete floors broom clean in unoccupied spaces.
- i. Mop or vacuum clean concrete/tile floors in occupied spaces.
- j. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
- k. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.
- l. Remove labels that are not permanent.
- m. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
- n. Vacuum inside and outside of all new and existing electrical panels, MCCs, variable speed drives, etc., which have been affected by dust or dirt due to construction activities.
- o. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
- p. Replace disposable air filters and clean permanent air filters. Vacuum clean exposed surfaces of diffusers, registers, and grills.

- q. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.
 - (1) Clean HVAC system in compliance with NADCA Standard 1992-01. Provide written report on completion of cleaning.
 - r. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
 - s. Leave Project clean and ready for occupancy.
- C. Electrical Contractor shall touch-up paint or repaint damaged finishes on electrical items delivered to Project with finish coat of paint. Engineer will make final determination of items to be repainted or touched-up.
- D. Prior to substantial completion or Owner occupancy, Contractor with Engineer and Owner, shall conduct inspection of sight-exposed interior and exterior surfaces and work areas to verify Work and site is clean.

3.03 CLEANING AND DISINFECTING OF CONCRETE TANKS:

- A. Comply with the requirements of AWWA C652: Disinfection of Water Storage Facilities. Refer to Section 33 13 00 for requirements.

END OF SECTION

SECTION 01 77 00
CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

- A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following as indicated and in compliance with Contract Documents:
 - 1. Substantial Completion procedures.
 - 2. Final completion procedures.
 - 3. Warranties.
 - 4. Final cleaning.
 - 5. Repair of the Work.
 - 6. Specific closeout and special cleaning requirements for the Work in those Sections.

1.03 SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. Product Data: For cleaning agents.
- C. Contractor's List of Incomplete Items: Initial submittal at Substantial Completion.
- D. Certified List of Incomplete Items: Final submittal at Final Completion.
- E. Certificates of Release: From authorities having jurisdiction.
- F. Certificate of Insurance: For continuing coverage.
- G. Field Report: For pest control inspection.
- H. Schedule of Maintenance Material Items: For maintenance material submittal items specified in other Sections.

1.04 SUBSTANTIAL COMPLETION PROCEDURES:

- A. Contractor's List of Incomplete Items: Prepare and submit a list of items to be completed and corrected (Contractor's punch list), indicating the value of each item on the list and reasons why the Work is incomplete.
- B. Submittals Prior to Substantial Completion: Complete the following a minimum of 20 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.
 - 1. Certificates of Release: Obtain and submit releases from authorities having jurisdiction permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
 - 2. Submit closeout submittals specified in other Division 01 Sections, including project record documents, operation and maintenance manuals, final completion construction photographic documentation, damage or settlement surveys, property surveys, and similar final record information.
 - 3. Submit closeout submittals specified in individual Divisions 02 through 33 Sections, including specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
 - 4. Submit maintenance material submittals specified in individual Sections, including tools, spare parts, extra materials, and similar items, and deliver to location designated by Engineer. Label with manufacturer's name and model number where applicable.
 - a. Schedule of Maintenance Material Items: Prepare and submit schedule of maintenance material submittal items, including name and quantity of each item and name and number of related Specification Section. Obtain Engineer's signature for receipt of submittals.
 - 5. Submit test/adjust/balance records.
 - 6. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.
- C. Procedures Prior to Substantial Completion: Complete the following a minimum of 20 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.
 - 1. Advise Owner of pending insurance changeover requirements.
 - 2. Make final changeover of permanent locks and deliver keys to Owner. Advise Owner's personnel of changeover in security provisions.

3. Complete startup and testing of systems and equipment.
 4. Perform preventive maintenance on equipment used prior to Substantial Completion.
 5. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video recordings specified in Division 01 Section "Training."
 6. Advise Owner of changeover in heat and other utilities.
 7. Participate with Owner in conducting inspection and walkthrough with local emergency responders.
 8. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
 9. Remove labels that are not permanent labels.
 10. Complete final cleaning requirements, including touchup painting.
 11. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.
- D. Inspection: Submit a written request for inspection to determine Substantial Completion a minimum of 10 days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Engineer, that must be completed or corrected before certificate will be issued.
1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
 2. Results of completed inspection will form the basis of requirements for final completion.

1.05 PROJECT RECORDS DOCUMENTS

- A. The Contractor shall record any actual revisions to the Work and maintain one set of the following Project Record Documents on Site:
1. Contract Drawings, Specifications, and Addenda.
 2. Change Orders, Field Orders, and other written notices.
 3. Shop drawings, Product data, and samples.

4. Records of surveying and layout Work.
 5. Project Record Drawings.
- B. The Contractor shall record information on the Project Record Documents concurrent with construction progress and store these documents separately from the documents used for construction.
1. The Owner will supply a set of Contract Drawings. The Contractor shall mark thereon all revisions as the Work progresses in order to produce a set of as-built drawings.
 2. The Contractor shall note any changes made during construction by any of the Contractor's forces or those of any Subcontractors.
 3. The Contractor shall dimension the locations of buried or concealed Work, especially piping and conduit, with reference to exposed structures.
 4. The Contractor shall dimension the installed locations of concealed service lines on the Site or within the structure by reference from the centre line of the service to the structure column lines, or other main finished faces, or other structural points which are easily identified and located in the finished Work.
 5. Certificates of Substantial Completion and Final Completion shall not be issued until Record Drawings are complete and submitted, and the Contractor has satisfied all requirements for Substantial Completion and Final Completion of the Work.
- C. For Project Record Documents and Record Shop Drawings, the Contractor shall legibly mark each item to record actual construction including:
1. Field changes of dimensions and details.
 2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
 3. Measured locations of internal utilities and appurtenances which are concealed in construction, referenced to visible and accessible features of the Work.
 4. Changes in the Work caused by Site conditions, or originated by the Owner, the Engineer, the Contractor, Preselected Equipment Vendors, or Subcontractors and by addenda, supplemental drawings, Site instructions, supplementary instructions, change orders, correspondence, and directions of any regulatory authorities.
 5. Record the location of concealed mechanical services and electrical main feeders, junction boxes and pullboxes.

- D. Upon completion of the Work, the Contractor shall provide electronic sets of the Record Shop Drawings and an index.

1. The Contractor shall remove the Architect/Engineer seal from all documents.
2. The Contractor shall provide a set of Project Record Documents in an electronic format. All drawings are to be provided electronically in both AutoCAD (latest version) and Adobe Acrobat PDF (latest version). Also provide a set of the software implemented on this project, including standard software and custom application software. Also provide a set of the various programming tools and files necessary for maintenance, editing, backing up and restoring programmable equipment implemented on this project.

1.06 EQUIPMENT INVENTORY SPREADSHEET

- A. As part of the Owner's asset management program, the Contractor shall complete all fields for the equipment inventory file for each piece of equipment and device provided under this Contract, as a requirement for Substantial Performance. An electronic format of the equipment inventory spreadsheet will be provided on a CD to the successful General Contractor.

1.07 EQUIPMENT PREVENTATIVE MAINTENANCE SPREADSHEET

- A. As part of the Owner's asset management program, the Contractor shall complete all fields for each piece of equipment and device provided under this Contract, as a requirement for Substantial Completion. The Contractor shall transfer all of the manufacturer's recommended preventative maintenance tasks and frequencies into the spreadsheet. An electronic format of the equipment inventory spreadsheet will be provided on a CD to the successful General Contractor

1.08 PROTECTING INSTALLED CONSTRUCTION:

- A. Protect installed Work and provide special protection where specified in individual specification sections.
- B. Provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.
- C. Provide protective coverings at walls, projections, jambs, sills, and soffits of openings.
- D. Protect finished floors, stairs, and other surfaces from traffic, dirt, wear, damage, or movement of heavy objects, by protecting with durable sheet materials.
- E. Prohibit traffic or storage upon waterproofed or roofed surfaces. When traffic or activity is necessary, obtain recommendations for protection from waterproofing or roofing material manufacturer.
- F. Prohibit traffic from landscaped areas.

1.09 SPARE PARTS AND MAINTENANCE PRODUCTS:

- A. Furnish spare parts, maintenance, and extra products in quantities specified in individual specification sections.
- B. Deliver to Project site and place in location as directed by Owner; obtain receipt prior to final payment.

1.10 FINAL COMPLETION PROCEDURES:

- A. Submittals Prior to Final Completion: Before requesting final inspection for determining final completion, complete the following:
 - 1. Submit a final Application for Payment according to Contract Documents.
 - 2. Certified List of Incomplete Items: Submit certified copy of Engineer's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Engineer. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
 - 3. Certificate of Insurance: Submit evidence of final, continuing insurance coverage complying with insurance requirements.
 - 4. Submit pest-control final inspection report.
- B. Inspection: Submit a written request for final inspection to determine acceptance a minimum of 10 days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.
 - 1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.11 LIST OF INCOMPLETE ITEMS (PUNCH LIST):

- A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.
 - 1. Organize list of spaces in sequential order, starting with exterior areas first and proceeding from lowest floor to highest floor.
 - 2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
 - 3. Include the following information at the top of each page:

- a. Project name.
 - b. Date.
 - c. Name of Engineer.
 - d. Name of Contractor.
 - e. Page number.
4. Submit list of incomplete items in the following format:
- a. MS Excel electronic file. Engineer will return annotated file.

1.12 SUBMITTAL OF PROJECT WARRANTIES:

- A. Time of Submittal: Submit written warranties on request of Engineer for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated, or when delay in submittal of warranties might limit Owner's rights under warranty.
- B. Partial Occupancy: Submit properly executed warranties within 15 days of completion of designated portions of the Work that are completed and occupied or used by Owner during construction period by separate agreement with Contractor.
- C. Organize warranty documents into an orderly sequence based on the table of contents of Contract Documents.
 1. Bind warranties and bonds in electronic format.
 2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.
 3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.
 4. Warranty Electronic File: Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide bookmarked table of contents at beginning of document.
- D. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 3 - EXECUTION

3.01 FINAL CLEANING:

- A. General: Perform final cleaning in accordance with Section 01 74 23.
- B. Pest Control: Comply with pest control requirements in Division 01 Section "Temporary Facilities" Prepare written report.
- C. Construction Waste Disposal: Comply with waste disposal requirements in Division 01 Section "Temporary Facilities".

3.02 REPAIR OF THE WORK:

- A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.
- B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.
 - 1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
 - 2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that already show evidence of repair or restoration.
 - a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.
 - 3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

3.03 ADJUSTING:

- A. Adjust operating products and equipment to ensure smooth and unhindered operation.

END OF SECTION

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section includes procedural requirements for providing, compiling, and submitting operation and maintenance data required for this project.

1.02 SUMMARY:

- A. This section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
 - 1. General contents of data.
 - 2. Specific data for each equipment and system.
 - 3. Manual for materials and finishes.
 - 4. Assembly.

1.03 DEFINITIONS:

- A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.
- B. Subsystem: A portion of a system with characteristics similar to a system.

1.04 SUBMITTALS:

- A. O&M Manual Content: Operations and maintenance manual submittal requirements are specified in individual Specification Sections for the Products for which they must be supplied. Submit reviewed manual content formatted and organized by this Section and in accordance with Section 01 33 00.
 - 1. Engineer will comment on whether content of operations and maintenance submittals are acceptable.
 - 2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.
- B. Pre-Final Manual Submittal: Submit one electronic copy of each manual in final form prior to requesting inspection for Substantial Completion. Engineer will return one copy with comments.

- C. The contractor to correct or revise each manual to comply with Engineer comments. After acceptance, deliver one electronic copy to the Engineer.
- D. Submit two hardcopies and one electronic copy of the final manual to the Owner within 15 days of receipt of Engineer's comments and prior to commencing startup, commissioning, and/or training.

1.05 FORMAT (HARDCOPY):

- A. Prepare data in the form of an O&M instructional manual.
- B. Binders: Commercial quality, 8-1/2 x 11-inch three-hole post type binders with hardback, 3-inch maximum binder size. When multiple binders are used, correlate data into related consistent groupings. Three ring binders are not acceptable.
- C. Arrange contents by Specification Section numbers and sequence of Table of Contents of this Project Manual.
- D. Provide tabbed fly leaf for each separate product and system, with printed description of product and major component parts of equipment. Insert type tab labels must be secured or bonded to prevent the labels from falling out.
- E. Text: Manufacturer's printed data, or typewritten data on 20 pound paper.
- F. Drawings: Provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages and insert into clear plastic envelopes that can be secured into the three-hole post binders.

1.06 FORMAT (ELECTRONIC DOCUMENTATION):

- A. The Contractor must provide Operation and Maintenance Manual information specific to the configuration of the project in electronic form. Documents should be formatted like a web site complete with index page and Table of Contents. The electronic format must be such that the Owner is able to load the files onto a server to provide online access via any standard web browser. The Manual shall be a searchable PDF file formats with hyperlinks.
- B. The electronic O&M data must be organized in a logical manner to aid operation in troubleshooting and information retrieval.

1.07 QUALITY ASSURANCE:

- A. Preparation of data shall be performed by personnel:
 - 1. Trained and experienced in O&M of described equipment.
 - 2. Familiar with requirements of this section.
 - 3. Skilled as technical writers to the extent required to communicate the essential data to the Reader.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 GENERAL CONTENTS OF DATA:

- A. Each individual manual shall contain equipment data pertaining to not more than one Specification section number as indicated in the Contract Documents.
- B. Title Sheet: First page in data listing following:
 - 1. Title: "OPERATION AND MAINTENANCE INSTRUCTIONS".
 - 2. Title of Project: As shown on Contract Documents.
 - 3. Name(s) of applicable building(s) or structure(s) in which equipment is located.
 - 4. Name of equipment as described in Contract Documents.
 - 5. Contractor's name, address, and telephone number.
 - 6. Subcontractor's name, address, and telephone number if equipment is provided by Subcontractor.
 - 7. Contractor's or Subcontractor's purchase order number, manufacturer's shop order number or other such numbers required for parts and service ordering.
 - 8. Manufacturer's name, address, and telephone number.
 - 9. Name, address, and telephone number for local source of supply for parts and service.
- C. Equipment List: Immediately following title sheet containing the following:
 - 1. Table of Contents: Immediately following equipment list. Arrange in logical, systematic order and shall include as minimum each tabbed divider. Each page shall be numbered.
 - 2. Tabbed Dividers: Insert tabbed section dividers between each major section
 - a. Provide title of section on each tab.
 - b. Provide table of contents for each tabbed section, arranged in systematic order.

3. Equipment Data Sheets: Provide catalog sheets showing configuration, manufacturer's specifications, models, options, and styles of equipment and major components being provided. Product data sheets will show project specific information with inapplicable information deleted by crossing out or removal. Include in tabbed section(s).
4. Text:
 - a. Include only those sheets applicable to Project.
 - b. Each sheet shall:
 - (1) Identify specific equipment or part installed.
 - (2) Identify text applicable to equipment or part installed.
 - (3) Do not include inapplicable information or neatly strike it out.
5. Drawings:
 - a. Supplement text with drawings to clearly illustrate following:
 - (1) Equipment and components.
 - (2) Relations of component parts of equipment and systems.
 - (3) Control and flow diagrams, wiring diagrams.
 - b. Actual drawings of equipment from manufacturer. "Typical" drawings are not acceptable unless they accurately illustrate actual installation for this contract.
6. Specially written information, as required to supplement text for particular installation.
 - a. Provide explanation of interrelationships of equipment and components, and effects one component has on another or entire system.
 - b. Provide overall instructions and procedures for equipment tying in instructions and procedures for separate components into unified instructional package.
 - c. Provide glossary of any special terms used by the manufacturer if applicable.
 - d. Organize in consistent format under separate headings for different O&M procedures.
 - e. Provide logical sequence of instructions in order of O&M action required for each procedure.

3.02 SPECIFIC DATA FOR EACH ITEM OF EQUIPMENT AND/OR SYSTEM:

A. For each item of equipment and system include:

1. Description of equipment and component parts:
 - a. Function
 - b. Normal operating characteristics
 - c. Limiting conditions.
 - d. Performance curves
 - e. Engineering data
 - f. Test as applicable.
 - g. Complete nomenclature and model number of replaceable parts including keyed labeled exploded diagram.
 - h. Complete nameplate data.
 - i. Owner's tag (or asset) numbers for equipment as indicated on the Contract Drawings.
2. Operating Procedures:
 - a. Startup and break-in.
 - b. Normal operating instructions.
 - c. Regulation and control
 - d. Stopping and shutdown,
 - e. Emergency instructions.
 - f. Summer and winter operating instructions, as applicable.
 - g. Special operating instructions.
3. Maintenance Procedures:
 - a. Routine maintenance operations.
 - b. Guide to troubleshooting.
 - c. Disassembly, repair, and reassembly instructions.

- d. Alignment, adjusting, and checking instructions.
 - 4. Servicing and Lubrication Schedule:
 - a. List of lubricants required and quantity to be applied.
 - b. Schedule of lubrication.
 - c. Schedule for other routine maintenance.
 - 5. Manufacturer's printed instructions regarding safety precautions for both (a) protection of personnel operating equipment and systems and (b) prevention of damage to equipment and systems.
 - 6. Description of sequence of operation of controls.
 - 7. Assembly drawings and diagrams required for maintenance.
 - 8. Manufacturer's parts list and illustrations
 - a. Predicted life of parts subject to wear.
 - b. Items recommended to be stocked by the Owner as spare parts and quantities of same.
 - 9. Accepted control diagrams such as ladder diagrams, instrumentation loop diagrams, and electrical schematics.
 - 10. Bill of material.
 - 11. Other data as required under applicable Specification sections.
- B. Each electric and electronic system, as applicable to equipment such as switchgear, motor control centers, panel boards, switchboards, starters, breakers, and relays shall include:
- 1. Description of System and Component Parts:
 - a. Function
 - b. Normal operating characteristics
 - c. Limiting conditions.
 - d. Performance curves
 - e. Engineering data
 - f. Rating tables

- g. Tests, as applicable.
 - h. Complete nomenclature and model number of replaceable parts.
 - i. Complete nameplate data.
 - j. Owner's Tag (asset) numbers for equipment as indicated on the Contract Drawings.
- 2. Circuit Directories of Panel Boards:
 - a. Electrical service.
 - b. Controls.
 - c. Communications.
 - 3. Complete instrumentation
 - a. Loop diagrams
 - b. Tabulated listing of components in each control circuit or loop.
 - 4. Operating Procedures:
 - a. Routine and normal operating instructions.
 - b. Sequences required.
 - c. Special operating instructions.
 - 5. Maintenance Procedures:
 - a. Routine maintenance operations.
 - b. Guide to troubleshooting.
 - c. Disassembly, repair, and reassembly instructions.
 - d. Adjustment and checking instructions.
 - 6. Manufacturer's printed instructions regarding safety precautions for both:
 - a. Protection of personnel operating equipment and systems.
 - b. Prevention of damage to equipment and systems.
 - 7. List of original all of the manufacturer's components, spare parts with diagram, and recommended quantities to be maintained in storage by the Owner.

8. Other data as required under pertinent sections of Specifications.

- C. Prepare and include additional data when need for such data becomes apparent during instruction of Owner's personnel. Differences between the equipment O&M manual and the manufacturers training session shall result in the training and/or O&M Manual being corrected.

3.03 MANUAL FOR MATERIALS AND FINISHES:

- A. Building Products, Applied Materials, and Finishes: Include product data, with catalog number, size, composition, and color and texture designations. Provide information for re-ordering custom manufactured products.
- B. Instructions for Care and Maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- C. Moisture Protection and Weather Exposed Products: Include product data listing applicable reference standards, chemical composition, and details of installation. Provide recommendations for inspections, maintenance, and repair.
- D. Additional Requirements: As specified in individual product specification sections.
- E. Provide a listing in Table of Contents for design data, with tabbed fly sheet and space for insertion of data.

3.04 ASSEMBLY:

- A. Insert index tabs labeled with the respective piece of equipment to separate individual manuals.
- B. Provide a Table of Contents at the front of each volume showing the equipment items in the order in which they appear in the volume. Each equipment items shall include the functional name, applicable specifications section, and the plan listing, if any.
- C. The preventive maintenance schedule shall be bound in the front of each section immediately following the index tab sheet. The schedule shall be identified with respect to the piece of equipment it is referring to.
- D. Sheet Size: 8-1/2 x 11 sheets. Drawings shall be on 11 x 17-inch sheets folded to 8-1/2 x 11 inches.
- E. Engrave on covers and end of binder, title OPERATIONS AND MAINTENANCE INSTRUCTIONS, name of Project, Owner's project number, date of Contract, and volume number with subject matter of contents, and Engineer's name.

END OF SECTION

SECTION 01 78 25

PLANT TESTING, STARTUP AND COMMISSIONING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide planning, functional completion testing, startup and commissioning as indicated and specified. Section includes:
 - 1. Plant Checkout Plan
 - 2. Functional Completion Testing
 - 3. Startup
 - 4. Commissioning

1.02 DEFINITIONS:

- A. The Plant Checkout Plan (the Plan) incorporates all aspects of functional completion testing, startup, commissioning, performance testing, training, and reliability tests to ensure the facility operates properly and meets design intent and performance.
- B. Functional Completion Testing is testing of the equipment and unit process systems to confirm that construction and installation has been completed in anticipation of initial startup of the equipment and unit process systems. Functional Completion Testing includes:
 - 1. Physical Checkout shall be defined as the process of physically inspecting products after they have been installed in the Work to determine if the Products have been properly and completely installed, and are ready for Field and/or Functional Testing. The requirements for Physical Checkout are contained in the pertinent technical specification(s) (if applicable) and in Paragraph 1.08 of this Section.
 - 2. Field Testing shall be defined as testing that is performed by the Contractor, with Supplier assistance, on Products after they have been installed in the Work, and after the performance of physical checkout, for the purpose of proving that the tested Products meet the requirements of the pertinent technical specifications. Administrative and minimum technical requirements for field testing are specified in Paragraph 1.08 of this Section, while additional technical requirements are contained in PART 3 of the pertinent technical specification(s). The test criteria are specified in Paragraph 1.08 of this Section.

- C. Startup shall be defined as the operation of equipment or unit process systems using clean water, air, or other fluids and gases as necessary to demonstrate the operation of the equipment or unit process systems with other equipment that is a part of, or a treatment process for the Facility. Administrative and minimum technical requirements for startup are specified in Paragraph 1.09 of this Section, while additional technical requirements are contained in PART 3 of the pertinent technical specification(s).
- D. Commissioning shall be defined as the operation of equipment or unit process systems using process liquids or process solids, plant support equipment, and plant utilities to demonstrate equipment or unit process systems are capable of processing water or wastewater at specified flows and conditions for a sustained period of operation as required by this section or equipment or unit process systems specifications. Successful Commissioning shall determine that the equipment or unit process systems are ready to begin Performance Testing. Administrative and minimum technical requirements for Commissioning are specified in Paragraph 1.10 of this Section, while additional technical requirements are contained in PART 3 of the pertinent technical specification(s).
- E. Performance Testing is defined as a test to demonstrate the specified throughput of the equipment and unit process systems while maintaining regulatory compliance with Federal, State, and Local government regulations and minimum compliance with the equipment or unit process systems performance requirements and guarantees.
- F. Reliability Testing is defined as a test performed as an extended operation of the constructed facilities to confirm that the equipment and unit process systems work together as a complete Facility under continuous operation for the specified period. The Reliability Test shall be conducted after all the major equipment and unit process systems have successfully completed Performance Testing in accordance with this Specification Section. Supplier's Representative, sometimes referred to in the technical specifications as a Factory-Trained Service Representative, shall be defined as a person, or persons provided by the Supplier, who is qualified by having the training and experience, to provide technical and/or process related advice, and/or assistance, relating to the installation or utilization of the Products provided by that same Supplier, for installation and utilization in the Work.
- G. The Testing and Checkout Coordinator shall be defined as the person provided by the Contractor to coordinate and oversee the total spectrum of testing and inspection activities required by the Contract Documents. The Testing and Checkout Coordinator shall have been in responsible charge of two similar Projects in the last four years.

1.03 ROLES AND RESPONSIBILITIES:

- A. The Contractor shall provide all outside services, materials, labor, supplies, test equipment and other items necessary to perform the Plant Testing, Startup and Commissioning specified herein. In addition, the Contractor shall arrange for and provide the participation or assistance of survey crews, quality control technicians, Supplier's representative(s), and required governmental agency representatives.

- B. The Contractor shall provide the services of the Supplier's representative(s) as follows:
 - 1. Assistance during installation as specified in PART 3 of the technical specifications and as specified herein.
 - 2. Field Testing as specified in PART 3 of the technical specifications and as specified herein.
 - 3. Startup as specified in PART 3 of the technical specifications and as specified herein.
 - 4. Commissioning as specified in PART 3 of the technical specifications and as specified herein.
- C. The Supplier's representative's activities required by this Section are in addition to the requirements for vendor training and other services specified elsewhere in the Contract Documents. Timing for the performance of these services is to be defined in the Contractors Checkout Plan, specified herein.
- D. The Engineer will review and comment on the Contractor's deliverables, participate in the physical inspection activities, witness the shop and field testing, witness functional testing, maintain the permanent record of all testing results, and provide verification of conformance to the specifications. The Engineer's right to perform inspections, witness tests or monitor or assess the Work and activities does not relieve the Contractor of its obligation to comply with the requirements of the Contract Documents nor does it imply completion of the Work.

1.04 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 - 1. Submit a Plant Checkout Plan and Functional Test Plan for the facility in accordance with Section 01 33 00.
- B. Qualification Data: For startup and commissioning team.
 - 1. Submit resumes, including three outside references, for each team member proposed for testing, startup, and commissioning. The qualifications of each team member shall include:
 - a. Type of training the team members has received for the specific equipment the startup and commissioning will cover, including dates and who provided the training.
 - b. Startup and commissioning work experience including the employers name and address, dates of employment and type of startup and commissioning provided and to whom.

- c. A minimum of five startup and commissioning references including: project name, project location, contact person's name, contact person's telephone number, contact person's role during the project, dates of startup and commissioning.
2. Engineer will review resumes. Based upon review of resumes, and contacts with references, Engineer will approve, request additional information, or reject proposed startup and commissioning team members.
3. If proposed startup and commissioning team member is rejected, Contractor shall submit resume and references on alternate team member(s) for acceptance.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 61 00.
- B. Preparation of the plant checkout plan, functional completion testing and startup and commissioning shall be performed by personnel:
 1. Trained and experienced in O&M of the described equipment.
 2. Familiar with the requirements of this section.

1.06 PLANT CHECKOUT PLAN:

- A. The Contractor shall be responsible for preparing, coordinating, and executing the Plan.
 1. The Contractor shall use the resources of the equipment and unit process systems suppliers in this work, particularly for specific equipment and unit process systems.
 2. An initial draft of the Plan shall be submitted as indicated here:
 - a. The initial draft Plan for the Facility shall be completed and submitted by the Contractor to the Engineer for review. The Engineer will require 45 days to review the submittal and return with any exceptions noted.
 - b. The Contractor shall incorporate the Engineer's comments into the revised Plan within 30 days of receiving comments, and reissue the Plan to the Engineer and Owner.
 - c. The Contractor shall regularly schedule meetings with the Engineer and Owner to review and coordinate activities required by the Plan.
- B. The Contractor shall provide a dedicated field staff to support the Plan activities. Contractor shall be responsible for day to day activities and shall be the primary contact with the Engineer regarding Plan activities. Support staff shall include but not be limited

to designated mechanical, electrical and instrumentation and control engineers and technicians, and operating staff.

C. The Plan shall define:

1. The logical and systematic performance of physical inspections, field and functional tests, startup, commissioning, performance testing and reliability testing including:
 - a. A chronological schedule of all testing and inspection activities.
 - b. A checklist of all inspection and testing activities broken down by location, discipline, system, and device or item.
 - c. All blank forms proposed by the Contractor for verification or recording of the functional completion testing, startup, commissioning, performance testing, and reliability testing.
 - d. An index which cross references the forms to their intended application(s).
 - e. A list of all supplier certifications, including those required by the applicable technical specifications. Provisions shall also be included for retesting, in the event it is required.
2. A list of participants in functional completion testing, startup, commissioning, performance testing and reliability testing.
3. A list of special test equipment required for functional completion testing, startup, commissioning, performance testing, and reliability testing.
4. Sources of the test media (water, power, air.) for functional completion testing.
5. The proposed method of delivery of the media to the equipment to be tested during functional completion testing, startup, commissioning, performance testing, and reliability testing.
6. Temporary or interim connections for the sequencing of multiple units during functional completion testing, startup, commissioning, performance testing, and reliability testing.
7. Ultimate disposal of the test media after functional completion testing, startup, commissioning, performance testing, and reliability testing.

1.07 FUNCTIONAL COMPLETION TESTING:

- A. Functional Completion Testing shall be completed as construction and installation of equipment is completed to demonstrate that the equipment is ready for equipment and unit process systems startup.

1. Functional Completion Testing shall be done in a coordinated manner based on the Plan prepared by the Contractor.
 - a. The Owner's operating and maintenance staff shall be allowed to observe for the purposes of familiarization and training.
 - b. Additional witnesses, such as the Engineer, may be present to represent the Owner.
2. Functional Completion Testing procedures and documentation forms shall be developed by the Contractor. The procedures shall include a listing of items inspected for Functional Completion Testing.
3. If any equipment or unit process systems do not meet Functional Completion Testing requirements, it shall be the responsibility of the Contractor and/or equipment suppliers to make the necessary corrections or replacements and repeat the test.
4. The equipment and unit process systems shall not be started up or put into service until the Functional Completion Testing is completed as evidenced by a completed Functional Completion Testing certificate for the equipment or subsystem.
5. Modifications to the equipment and unit process systems required to meet Functional Completion Testing requirements shall be provided, and all retesting shall be performed at no additional cost to the Owner.
6. A Functional Completion Testing Certificate shall be prepared by the Contractor for each piece of equipment or unit process and submitted to the Engineer and Owner for review.

1.08 STARTUP:

- A. Startup activities for the Facility shall not be initiated until the requirements of Functional Completion Testing are completed for the equipment or unit process systems.
- B. The Contractor shall be responsible for startup.
 1. The Owner's operating and maintenance staff shall be allowed to observe for the purposes of familiarization and training.
 2. Additional witnesses, such as the Engineer, may be present to represent the Owner.
- C. For equipment or unit process systems that do not meet the specified Startup requirements, it shall be the responsibility of the Contractor and/or equipment or unit process systems suppliers to make the necessary corrections or replacements and repeat Startup at no additional cost to the Owner.

1.09 COMMISSIONING:

- A. Commissioning activities for the Facility shall not be initiated until the requirements of Startup are completed for the equipment or unit process systems.
- B. Commissioning shall be used by the Contractor and equipment or unit process suppliers to adjust, fine tune, modify and prepare the equipment or system for continuous operation and Performance Testing.
 - 1. Equipment shall not be operated without the guidance of qualified personnel having the knowledge and experience necessary to conduct proper operation thereof and obtain valid results.
 - 2. All required adjustments, tests, operation checks, and Startup and Commissioning activities shall be provided by qualified personnel.
 - 3. Contractor shall be responsible for planning, supervising, and executing the Startup and Commissioning of the equipment and unit process systems with the assistance of equipment or unit process systems suppliers in accordance with the Plan.
- C. The Contractor shall support the Owner in commissioning.
 - 1. The Owner's operating and maintenance staff shall be allowed to observe for the purposes of familiarization and training.
 - 2. Additional witnesses, such as the Engineer, may be present to represent the Owner.
- D. For equipment or unit process systems that do not meet Commissioning requirements, it shall be the responsibility of the Contractor and/or equipment or unit process systems suppliers to make the necessary corrections or replacements and repeat Commissioning at no additional cost to the Owner.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 PLANT CHECKOUT PLAN:

- A. The Plan shall include the following items as a minimum:
 - 1. Cover Sheet with Plant identification, title, date and other information as needed to properly identify the specific information for the Facility.

2. Status and revisions sheet with appropriate dates and signatures spaces to document the development and status of the document.
3. Table of Contents including Appendix.
4. Equipment and systems descriptions with anticipated break down for individual startup activities. This section shall define the individual “packages” for startup activities for the equipment or unit process systems.
5. Schedule of events for startup and other activities covered by the Plan.
 - a. The schedule shall define dates for completing activities for equipment and unit process systems.
 - b. The schedule shall be the Contractor’s best estimate of time sequence at the time of issuance.
 - c. The Contractor shall submit monthly schedule updates to the Plan.
 - d. The schedule shall follow the required sequencing as specified herein.
6. Sign-off sheets consisting of certification forms or completion reports required by the specifications shall be included in the Plan. Standard forms shall be developed by the Contractor for this purpose.
7. Reports, test results and other supporting data shall be collected by the Contractor for documentation of the specific details leading to the certification or completion.

3.02 FUNCTIONAL COMPLETION TESTING:

- A. Provide 30 days written notice to the Engineer for each functional completion test so that the Engineer, may witness the functional completion tests. The Engineer may witness the performance of any or all functional completion testing, at their option.
- B. Testing shall be conducted in accordance with the accepted Plan using applicable standard techniques reviewed by the Engineer and Owner.
 1. Local and remote instrumentation may be used to record test data where it is determined the devices have been calibrated and sufficient to obtain necessary data.
- C. The Contractor shall develop standard data sheets to document Functional Completion Testing requirements have been met for all equipment and unit process systems included in the Plan.
 1. As equipment testing is completed the appropriate data sheet shall be completed and signed by the responsible party and submitted to the Engineer for review and acceptance.

2. Data values shall be stated in the engineering units noted in the equipment specifications.
- D. In the event no reference to procedures is made, or no procedures for startup and commissioning are contained in a technical specification for the following test parameters, the following shall be the checkout requirements. Should these requirements conflict with the Supplier's recommendations or in any way be less stringent than the Supplier's requirements, they shall be superseded by the Supplier's requirements for checkout testing.
1. Measurement of wearing ring clearances for all pumps requiring assembly, so equipped:
 - a. Take two readings taken opposed to each other by 90 degrees.
 - b. All measured clearances shall be within Supplier's specifications for new installations. Replace and recheck rings found to be out of round or out of specified tolerance.
 2. Measurement of Impeller Bore for all pumps requiring assembly:
 - a. Take two readings opposed to each other by 90 degrees.
 - b. All measured clearances shall be within Supplier's specifications for new installations. Replace and recheck impellers found to be out of round or out of specified tolerance.
 3. Measurement of shaft runout for all rotating equipment requiring assembly:
 - a. Remove bearings from the shaft. Support shaft on pedestal rollers or in a lathe.
 - b. Check each shoulder on the shaft.
 - c. Take two readings for each shoulder, opposed to each other by 90 degrees.
 - d. All measured clearances shall be within Supplier's specifications for new installations. Replace and recheck shafts found to be out of round or out of specified tolerance.
 4. Vibration Measurements:
 - a. Provide vibrational signature testing and documentation for each piece of direct drive or close coupled rotating equipment with a motor HP of 100 or above and a rated operating speed in excess of 1999 RPM.

- b. Unless specified otherwise, the current edition of the Hydraulic Institute Standard, "Acceptable Field Vibration Limits" shall be the standard for vibrational testing.
- c. Take all specified vibrational readings in three directions: vertical, horizontal, and axial.
- d. Provide vibrational measurements in the following engineering units:
 - (1) Displacement in thousandths of an inch (mils), peak to peak.
 - (2) Velocity in inches per second (ips), peak to peak.
 - (3) Acceleration in feet per second per second (1g=32.3 ft/sec./sec.) zero to peak.
 - (4) Spike energy in g-SE.
 - (5) The vibrational readings shall be less than the device rotating frequency, and within the operating band specified by the Supplier.
 - (6) Amplitude Allowable Maximums:

RPM	Amplitude inches peak to peak:
3,000 and above	0.001
1,500 - 2,999	0.002
1,000 - 1,499	0.0025
999 and below	0.003

- 5. Belt Drives:
 - a. All belts shall ride within the sheave and not slip to the bottom of the groove(s).
 - b. Belt tension shall be in accordance with Supplier's recommendations.
 - c. Pulley alignment shall be within Supplier's recommendations.
- 6. Gear Drives and Reducers:
 - a. Check gears for lash at no less than three points around the gear.
 - b. Rotate gears a full 360 degrees while checking alignment.
- 7. Coupling/Shaft Alignment:
 - a. Perform all final alignments and checks with a dial indicator or a laser device. Feeler gauges and straight edges are not acceptable.

- b. Eliminate soft foot conditions prior to aligning.
 - c. When checking for final soft foot, any displacement in excess of 0.002" must be corrected.
 - d. When checking for pipe strain, any displacement in excess of 0.002" requires piping realignment.
 - e. Alignments will not be regarded as final until the grout is set and all piping has been attached. Demonstrate that alignment is not changed by attachment of piping.
 - f. Shim the driving element, never the driven element.
 - g. Take bracket sag corrections into account when using a dial indicator. Bracket sag shall be determined on a rigid pipe.
 - h. Mount a dial indicator to the driven element so that it can be rotated. Rotate both elements while aligning.
 - i. When aligning three coupled elements, align gear reduction elements with the driven element first, then align the driver to the gear reduction element.
 - j. Check all four alignments, i.e., angular alignment in the vertical and horizontal planes, and parallel alignment in the vertical and horizontal planes.
 - k. The acceptable alignment accuracy for flexible couplings is +0.005 inches, or the Supplier's specifications, whichever is more stringent.
 - l. The dial indicator must be perpendicular to the alignment surface.
 - m. Number hold down nuts prior to tightening. Loosen in reverse order. Tighten in ascending order.
 - n. Use only clean, deburred shims. Clean the machine base and feet from rust or burrs prior to alignment.
8. Measurement of Noise (dB):
- a. Eliminate noise sources generated by adjacent construction activity prior to testing.
 - b. Establish a background noise level prior to testing.
 - c. Perform noise level testing on each installed device as required by the technical specifications.

- d. The maximum noise level exposure is 85 dBA over eight hours continuous for office, shop, and other areas where the Owner's personnel will be performing their assigned duties.

9. Hydrostatic Testing:

- a. AWWA C600 standards latest edition are the standards for all hydrostatic testing.
- b. Visually inspect all welds prior to testing, for cracks, undercut on surface greater than 1/32-inches deep, lack of fusion on surface, reinforcement greater than Table 127.4.2 located in ANSI B31.1 Power Piping, and incomplete penetration (when accessible). Repair or rework as directed by the Engineer.
- c. At no time during hydrostatic testing shall any part of the piping system be subjected to a stress greater than 90 percent of its yield strength at test temperature.
- d. After 10 minutes of full hydrostatic test pressures, make an examination for leakage of all joints, connections, and all regions of high stress, such as around openings and thickness transition sections.
- e. Unless otherwise specified, the minimum required hydrostatic test pressure shall be 1.5 times the design pressure as specified and as indicated.
- f. Pressure holding time shall be 10 minutes plus the time required to inspect for leakage.
- g. Maximum pressure shall not exceed the maximum rated pressure for any component in the system being tested.

10. Electrical Equipment:

- a. The testing standards for electrical components are those contained in Section 26 05 10 and the pertinent technical specification(s).

E. Where required by the equipment specifications, the Contactor shall furnish an authorized, competent representative of the equipment or unit process supplier to supervise and coordinate the Functional Completion Testing program.

- 1. Instrument readings and other test data shall be tabulated by the Contractor.

F. Documentation Requirements:

- 1. Certificates are required for all Functional Completion Testing for equipment and unit process systems. Four copies of the completed certificates shall be supplied for review by the Engineer. Contents of the certificate shall be at a minimum:

- a. Contractor Review Comments, and Approval Page. This page shall include Certification by the preparer that he/she is the person responsible for the test data and the data is authentic and accurate. This page shall include a listing and signature of all witnesses to the test
- b. Equipment Suppliers Review Comments, and Approval Page. This page shall include Certification by the equipment or unit process systems suppliers that the equipment or unit process systems are properly installed and suitable for startup.
- c. Engineer Review Comments, and Approval Page.
- d. Process, Equipment, and P&IDs Involved in this Functional Completion Test
- e. Functional Completion Test Schedule
- f. Test Descriptions/Procedures
 - (1) Equipment or unit process systems tested.
 - (2) Test dates.
 - (3) Electrical Inspection and Tests
 - (4) Test results.
 - (5) Any repairs or corrections required to obtain acceptable test results.
 - (6) Calibration sheet for instrumentation or devices used for testing but not part of plant installation.
 - (7) Copies of calibration records for plant installed instrumentation
- g. Certify Mechanics and Installation. Inspection and certification to be conducted by equipment representative. Inspect and certify that each piece of equipment meets the following requirements:
 - (1) Not damaged in transportation or installation.
 - (2) Properly installed with no undue force imposed from piping or supports.
 - (3) Is properly lubricated.
 - (4) Motor rotation is correct.
 - (5) Free of overheating.

- (6) Free of vibration.
- (7) Free of noise.
- (8) Functions without overloading.
- (9) Piping and other connections are completed.
- (10) No leaks at equipment connections (static pressure testing).
- h. Certify Electric Valve Mechanics and Installation
- i. Inspect and certify that each valve meets the following requirements:
 - (1) Not damaged in transportation or installation.
 - (2) Properly installed with no undue force imposed from piping or supports.
 - (3) Is properly lubricated.
 - (4) Motor rotation is correct.
 - (5) Free of overheating.
 - (6) Free of vibration.
 - (7) Free of noise.
 - (8) Functions without overloading.
 - (9) Piping and other connections are completed.
 - (10) No leaks at equipment connections (static pressure testing).
- j. Inspection and certification to be conducted by Contractor.
- k. Instrumentation and Control Inspection and Tests
- l. Inspect and certify instrumentation and control circuits for the following:
 - (1) Loop checks have been completed for all signal and control circuits.
 - (2) All instruments have been calibrated.
 - (3) All instrumentation tubing has been pressure tested and any leaks repaired.
 - (4) Manual modes function as intended.

- (5) Protective interlocks function as intended.
 - (6) Remote modes function as intended.
 - (7) Automatic modes function as intended.
- m. Instrumentation tests include the following:
 - (1) Complete loop checks for all signals and controls. Control panel operates process properly in automatic mode.
- 2. Tests certificates shall be submitted no later than 30calendar days, after testing ends. The Engineer and Owner shall have no more than 30calendar days to complete a review and return with any exceptions noted.

3.03 STARTUP:

- A. Provide 30 days written notice to the Engineer for each startup procedure so that the Engineer, may witness each startup procedure. The Engineer may witness the performance of any or all each startup procedure, at their option.
- B. Startup shall begin at the conclusion of Functional Completion Testing, when the equipment or unit process systems are subjected to full operation using a process flow substitute.
 - 1. Startup activities shall be carried out with clean water or air, or other flows as required to show the equipment and unit process systems are functional.
 - 2. Process flows or process solids shall not be used for Startup.
 - 3. The various vendors, equipment suppliers and manufacturers shall provide on-site supervision and assistance for Startup services for the new facility.
- C. The Contractor shall coordinate all startup activities for equipment and unit process systems in accordance with the accepted Plan. The Contractor shall develop a detailed Startup plan as part of that Plan that includes the following as a minimum:
 - 1. Description of the overall, general startup process.
 - 2. List of equipment and unit process systems included for Startup activities.
 - 3. Detailed startup sequence of activities.
 - 4. Equipment and system boundaries as shown using marked-up P&IDs.
 - 5. Listing of staff and responsibilities for activities.
- D. Startup Requirements: The following are minimum requirements for completion of Startup activities:

1. Startup shall show that the equipment or unit process systems are suitable for continuous operation using clean water and other fluids or gases (no process fluids or solids) and that the flows and operating parameters are in compliance with specified design conditions.
 - a. Startup shall also demonstrate that local and remote instrumentation and controls are functioning properly and communicating with each other properly.
 - b. Equipment or unit processes shall be operated for a minimum of 10 days without interruptions in service.
 - c. If the startup fails, the contractor will be responsible for redoing the startup testing at no additional costs to the Owner.

E. Documentation Requirements:

1. A Startup certificate shall be prepared and submitted to the Engineer for review and returned with any exceptions noted. The reports shall include, but not be limited to, the following:
2. Contents of the certificate shall be at a minimum:
 - a. Contractor Review Comments and Approval Page. This page shall include Certification by the preparer that he/she is the person responsible for the test data and the data is authentic and accurate. This page shall include a listing and signature of all witnesses to the test. Certification by the Contractor that the equipment or the unit process systems were operated continuously for the specified period and that the equipment or unit process systems operated in compliance with the specified operating conditions, parameters and performance; and that the equipment or unit process systems are suitable for Commissioning.
 - b. Equipment Suppliers Review Comments and Approval Page. This page shall include Certification by the equipment or unit process systems suppliers that the equipment or unit process systems have been started up properly and operated within the design parameters. Certification by the equipment or unit process systems supplier that the equipment or the unit process systems were operated continuously for the specified period and that the equipment or unit process systems operated in compliance with the specified operating conditions, parameters and performance; and that the equipment or unit process systems are suitable for Commissioning.
 - c. Engineer Review Comments, and Approval Page.
 - d. Process, Equipment, and P&IDs Involved in this startup test.
 - e. Startup Schedule

f. Test Descriptions/Procedures

- (1) Equipment or unit process systems tested.
- (2) Test dates.
- (3) Electrical Inspection and Tests
- (4) Test results.
- (5) Any repairs or corrections required to obtain acceptable test results.
- (6) Calibration sheet for instrumentation or devices used for testing but not part of plant installation.

g. Appendix:

- (1) A summary of all data used in the calculations, including source, formulas with all terms defined.
- (2) Calculations for all data submitted, fully defined.
- (3) Copies of all raw field data sheets, including those indicating sampling point locations, and notes.
- (4) Production and/or operational data.
- (5) Calibration procedures and work sheets for sampling equipment.
- (6) Copies of calibration records for instrumentation.

3.04 COMMISSIONING:

- A. Provide 30 days written notice to the Engineer for each commissioning procedure so that the Engineer, may witness each commissioning procedure. The Engineer may witness the performance of any or all each commissioning procedure, at their option
- B. Commissioning shall begin at the conclusion of Startup Testing, wherein the equipment or unit process systems are subjected to full operation using the process flows.
 1. On successful completion of Startup, process flows and solids shall be used for commissioning the equipment and unit process systems to show the equipment and unit process systems function properly. Commissioning shall confirm the proper operation of the equipment and unit process systems with process fluids and process solids, adjustments shall be made, and the equipment or unit process systems shall be optimized and brought into compliance with design criteria.

2. Commissioning shall not be initiated with process flows and solids until the available flows and/or solids are representative of that required for the equipment or unit process systems for testing.
 3. The various vendors, equipment suppliers and manufacturers shall provide on-site supervision and assistance for Commissioning services for the new facility.
- C. The Contractor shall coordinate all Commissioning activities for equipment and unit process systems in accordance with the accepted Plan. The Contractor shall develop a detailed Commissioning plan as part of that Plan that includes the following as a minimum:
1. Description of the overall, general Commissioning process.
 2. List of equipment and unit process systems included for Commissioning activities.
 3. Detailed Commissioning sequence of activities.
 4. Equipment and system boundaries as shown using marked-up P&IDs.
 5. Listing of staff and responsibilities for activities.
- D. Commissioning Requirements: The following are minimum requirements for completion of Commissioning activities:
1. Commissioning shall show that the equipment and unit process systems are capable of continuous operation using process liquids and solids, chemicals, and utilities; and that the flows, operating parameters and performance requirements have been demonstrated for a minimum of 10 days of continuous operation, or the period required in the equipment specifications, whichever is longer.
 - a. Shutdowns that occur because of power outages, acts of God, failure of support systems not part of this contract will not be a cause of failure of the 10 days of continuous operation..
 2. If the commissioning fails, the contractor will be responsible for redoing the commissioning at no additional costs to the Owner.
- E. Training
1. Following successful equipment commissioning, conduct training for major pieces of equipment and SCADA systems.
 2. Training sessions shall be conducted by a qualified representative of the equipment manufacturer or the Owner. SCADA system training shall be conducted by the SCADA system integrator with plant personnel over the duration of project once controls screens begin development.

3. Durations and requirements of the equipment to receive training is specified in the individual equipment specification sections.
4. Provide an outline of planned training schedules to the Engineer for review. At a minimum, the agenda for equipment training shall include basic function, start-up and shut-down procedures, normal operational procedures, and normal maintenance.
5. The contractor shall video record, with audio, each session. Provide a separate media file (such as a DVD, usb, etc.) for each piece of equipment unless otherwise approved.

F. Documentation Requirements:

1. A Commissioning report shall be prepared and submitted to the Engineer for review and return with any exceptions noted. The reports shall include, but not be limited to, the following:
 - a. Contractor Review Comments and Approval Page. This page shall include Certification by the preparer that he/she is the person responsible for the test data and the data is authentic and accurate. This page shall include a listing and signature of all witnesses to the test. Certification by the Contractor that the equipment or the unit process systems were operated continuously for the specified period and that the equipment or unit process systems operated in compliance with the specified operating conditions, parameters and performance; and that the equipment or unit process systems are suitable for Performance Testing.
 - b. Equipment Suppliers Review Comments and Approval Page. This page shall include Certification by the equipment or unit process systems suppliers that the equipment or unit process systems have been commissioned properly and operated within the design parameters. Certification by the equipment or unit process systems supplier that the equipment or the unit process systems were operated continuously for the specified period and that the equipment or unit process systems operated in compliance with the specified operating conditions, parameters and performance; and that the equipment or unit process systems are suitable for Performance Testing.
 - c. Engineer Review Comments, and Approval Page.
 - d. Process, Equipment, and P&IDs Involved in this commissioning test.
 - e. Commissioning Schedule
 - f. Test Descriptions/Procedures
 - (1) Equipment or unit process systems tested.

- (2) Test dates.
- (3) Electrical Inspection and Tests
- (4) Test results.
- (5) Any repairs or corrections required to obtain acceptable test results.
- (6) Calibration sheet for instrumentation or devices used for testing but not part of plant installation.

g. Appendix:

- (1) A summary of all data used in the calculations, including source, formulas with all terms defined.
- (2) Calculations for all data submitted, fully defined.
- (3) Copies of all raw field data sheets, including those indicating sampling point locations, and notes.
- (4) Production and/or operational data.
- (5) Calibration procedures and work sheets for sampling equipment.
- (6) Copies of calibration records for instrumentation.
- (7) Commissioning Documentation and Reports

END OF SECTION

SECTION 01 78 27
RELIABILITY TEST

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies the Reliability Test work required as a basis for completion of the project.
 - 1. The Reliability Test is an extended operation test as part of the overall Completion Testing requirement.
 - 2. The Reliability Test shall be scheduled as specified herein and in accordance with Section 01 78 25.
- B. An extended operation Reliability Test shall be completed for the constructed facilities to confirm that the equipment and unit process systems provided by this contract work together as a complete Facility under continuous operation for the specified time period.
 - 1. The Reliability Test shall be conducted after all the major equipment and unit process systems have successfully completed commissioning and training.
- C. The Contractor will provide guidance for managing, supervising, and directing the Owner's designated operating and maintenance staff during the Reliability Test.
 - 1. The Contractor shall provide the services of equipment and systems suppliers to assist.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 RELIABILITY TEST PLAN:

- A. A detailed test plan shall be prepared and submitted to the Engineer for review and returned with comments prior to commencing the Reliability Test. The plan shall be prepared by the Contractor in conjunction with the equipment or unit process suppliers with review by the Engineer. Minimum requirements of the Reliability Test Plan shall be:
 - 1. A description of the schedule of events.
 - 2. A description of the instrument readings required and frequency of readings.

3. Daily data log sheets to be used that show data to be collected, frequency of recording, and location where readings will be taken. A description of the laboratory analysis required and procedures to be used.
4. The Owner shall analyze the samples in their laboratory or send samples to a certified laboratory for analysis. Testing shall be completed in accordance with Standards Methods for the Examination of Water and Wastewater, latest edition.
5. A description of the task assignments for data collection and how data will be assembled.
6. A description of sampling and analytical methods used.
7. Sample data certification sheet attesting that the data is accurate and authentic.

3.02 RELIABILITY TESTING:

- A. For the Performance and Reliability Test, equipment and unit process systems shall be operated to obtain stable operating conditions, typical of normal operation of the facility.
- B. Reliability Test operating data, shall be collected and submitted to the Engineer and Owner on a daily basis for review.
- C. Local and remote on-site instrumentation equipment shall be used to obtain necessary data to document operating parameters. Where local instrumentation is available, manual logging of the data shall be done in conjunction with the instrumentation readings to verify remote instrumentation readings. The operating data will be used by the Engineer to determine the successful completion of the test.
 1. The Facility shall be operated continuously for the period of 30 days to demonstrate sustainable, reliable operation while processing the normal plant process flows.
 - a. For the Reliability Test, plant data shall be collected and recorded to show that the Facility was operated in accordance with normal ranges and performance parameters for the facility and normal plant flow.
 - b. Components of the systems shall be those items associated with the system being operated and not a part of other idle systems.
 - c. Up to 4 hour shutdown periods for maintenance will be allowed during the test period. Shutdowns that occur because of utility power outages, acts of God, or failure of support systems not part of this contract, are exempt from the allowed shutdown periods. Operation of standby equipment or processes shall not be allowed unless part of the constructed system. If more than the allowed shut downs occur, corrective measures shall be taken by the Contractor and the test shall be re-run in its entirety at no additional cost to the Owner.

3.03 TEST COORDINATION:

- A. The Owner shall be responsible for staffing and operating the Facility for the Reliability Test.
- B. The Contactor shall furnish authorized competent representatives of the equipment or unit process systems suppliers to attend and assist with the Reliability Test.
 - 1. The equipment and unit process systems shall not be solely operated by these representatives.
 - 2. All modifications to operations must be through the Contractor and any changes in operation recommended by these representatives shall be thoroughly explained and documented to the operating staff.

3.04 DATA ACQUISITION AND ANALYSIS:

- A. Methods of data collection and analysis used for Reliability Testing to show compliance shall be as required by regulatory agencies, industry standards and as specified for that equipment or unit process.
- B. In addition to success operation of equipment including instrumentation and controls, motors, actuated valves, packaged process equipment, etc., collect the following minimum water quality data:
 - 1. Raw water turbidity, continuously collected and trended with plant instrumentation
 - 2. UF filtrate turbidity for each filter skid, continuously collected and trended with plant instrumentation.
 - 3. Raw water total suspended solids, collected three times per week.
 - 4. Raw water total alkalinity, pH, temperature, calcium, magnesium, arsenic, iron, manganese, aluminum, chloride, sulfate, bromide, total organic carbon, and total dissolved solids, collected once per week.
 - 5. UF backwash recycle total suspended solids, collected three times per week
 - 6. UF backwash recycle arsenic, collected once per week.
 - 7. Finished water pH (daily), free chlorine residual (daily), and total organic carbon (once per week).
 - 8. UF cleaning waste pH and chlorine residual sent to sewer, when a clean occurs or daily if multiple cleans occur.
 - 9. UF backwash waste total suspended solids sent to sewer, three times per week
 - 10. Volumes or weights of all chemicals used during the 30-day operational period.

11. Pressures at all pressure transmitters, continuously collected and trended with plant instrumentation.
12. Flows at all flow meters, continuously collected and trended with plant instrumentation.
13. Results of every membrane skid air integrity tests (pressure decay tests) including the calculated LRV. Required daily for each skid and following any clean-in-place procedure.

3.05 CERTIFICATION OF DATA:

- A. Certification of data will be required of the Contractor.

3.06 TEST FAILURE:

- A. Plant operating data shall be used to determine that the Facility has successfully completed the Reliability Test. If at any time the daily data does not indicate acceptable operation, the Engineer will notify the Contractor to change or modify operation to bring the operation back into acceptable ranges.
- B. In the event that the Reliability Test was not successfully completed, the Contractor shall repeat the test at no additional cost to the Owner.

3.01 REPORTS:

- A. Reports are required for all tests specified in the individual specifications for equipment and unit process. Report shall be provided by the manufacturer/supplier to the Engineer for review and returned with any exceptions noted.
- B. Test reports shall be submitted no later than 30 calendar days after testing ends. The Contractor shall assist and furnish required information in a timely manner including operating data sheets.
- C. The reports shall include, but not be limited to, the following:
 1. Cover. Including name and location of the plant, the equipment or unit process systems tested, name and address of the testing organization, and dates of the test.
 2. Certification. A page including a certification by the report preparer that he/she is the person responsible for the test data, and one by the Contractor or equipment or unit process systems certifying authenticity and accuracy of the report.
 3. Table of Contents.
 4. Introduction. Pertinent background information shall be presented in this Section. The information shall include, but not be limited to, the following:
 - a. Equipment or unit process systems tested.

- b. Test purpose.
 - c. Name and address of supplier, and testing organization.
 - d. Test dates.
 - e. Items or performance criteria tested.
 - f. Names of persons present for test.
 - g. Any other important background information.
5. Summary. A comprehensive summary of the test results with sufficient information and data necessary to evaluate the process with respect to the applicable performance specifications. This information shall include, but not be limited to, the following:
- a. A summary of the test results.
 - b. Comparison of test results with required performance criteria.
 - c. Process and operation data or parameters that can be used to verify operation at performance criteria.
 - d. A description and results of any analyses of samples collected during the test that supports the test results.
 - e. Discussion of errors, both real and apparent, in the test.
6. Methods. A description of the sampling and analytical methods used.
7. Operation. Facility Operation during Testing shall contain:
- a. Presentation of the process data for the test, with calculations where necessary to show the solids throughput or production to demonstrate that the operating conditions are sufficiently representative of those required for testing. Calculations may be included in the Appendix.
 - b. Process and control equipment flow diagram.
8. Appendix.
- a. A summary of all data used in the calculations, including source, formulas with all terms defined.
 - b. Calculations for all data submitted, fully defined.
 - c. Copies of all raw field data sheets, including those indicating sampling point locations, and notes.

- d. Laboratory reports, complete with analytical data sheets and chain of custody list.
- e. Production and/or operational data.
- f. Calibration procedures and work sheets for sampling equipment.
- g. Copies of calibration records for instrumentation.
- h. Pertinent correspondence concerning the test.
- i. Any other information necessary to assist the Owner in making a determination of compliance with the contract documents or to assist the Agency in making a determination of compliance with Federal, State, and Local regulations.

3.07 LETTER OF COMPLETION:

- A. After review and return with any exceptions noted of Reliability Testing Report, the Engineer shall provide a Letter of Completion (with exceptions noted) to the Contractor for the Facility.

END OF SECTION

SECTION 01 78 36

WARRANTIES AND BONDS

PART 1 - GENERAL

1.01 SCOPE OF WORK:

- A. This Section specifies general administrative and procedural requirements for warranties and bonds required by the Contract Documents, including manufacturer's standard warranties on products and special warranties.

1.02 DEFINITIONS:

- A. Standard Product Warranties are pre-printed written warranties published by individual manufacturers for particular products and are specifically endorsed by the manufacturer to the Owner.
- B. Special Warranties are written warranties required by or incorporated in the Contract Documents, either to extend time limits provided by standard warranties or to provide greater rights for the Owner.
- C. Standard Product Warranties and Special Warranties shall start on the date established as the date of Substantial Completion.

1.03 RELATED WORK:

- A. Refer to Conditions of Contract for the general requirements relating to warranties and bonds.
- B. General closeout requirements are included in Section 01 77 00.
- C. Specific requirements for warranties for the Work and products and installations that are specified to be warranted, are included in the individual Technical Sections.
- D. Certifications and other commitments and agreements for continuing services to Owner are specified elsewhere in the Contract Documents.

1.04 SUBMITTALS:

- A. Submit written warranties to the Owner prior to the date fixed by the Engineer for Substantial Completion. If the Certificate of Substantial Completion designates a commencement date for warranties other than the date of Substantial Completion for the Work, or a designated portion of the Work, submit written warranties upon request of the Owner.
- B. When a designated portion of the Work is completed and occupied or used by the Owner, by separate agreement with the Contractor during the construction period, submit properly

executed warranties to the Owner within fifteen days of completion of that designated portion of the Work.

- C. When a special warranty is required to be executed by the Contractor, or the Contractor and a subcontractor, supplier or manufacturer, prepare a written document that contains appropriate terms and identification, ready for execution by the required parties. Submit a draft to the Engineer for acceptance prior to final execution.
- D. Refer to individual Technical Sections for specific content requirements, and particular requirements for submittal of special warranties.
- E. At Final Completion, compile two copies of each required warranty and bond properly executed by the Contractor, or by the Contractor, subcontractor, supplier, or manufacturer. Organize the warranty documents into an orderly sequence based on the table of contents of the Contract Documents.
 - 1. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Contract Documents, with each item identified with the number and title of the specification Section in which specified, and the name of the product or work item.
 - 2. Document shall be searchable and not contain any scans or photographs.
 - 3. Provide a typed description of the product or installation, including the name of the product, and the name, address and telephone number of the installer, supplier, and manufacturer.

1.05 WARRANTY REQUIREMENT:

- A. Related Damages and Losses: When correcting warranted Work that has failed, remove and replace other Work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted Work.
- B. Reinstatement of Warranty: When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.
- C. Replacement Cost: Upon determination that Work covered by a warranty has failed, replace or rebuild the Work to an acceptable condition complying with requirements of Contract Documents. The Contractor is responsible for the cost of replacing or rebuilding defective Work regardless of whether the Owner has benefited from use of the Work through a portion of its anticipated useful service life.
- D. Owner's Recourse: Written warranties made to the Owner are in addition to implied warranties, and shall not limit the duties, obligations, rights and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitations on time in which the Owner can enforce such other duties, obligations, rights or remedies.

- E. Rejection of Warranties: The Owner reserves the right to reject warranties and to limit selections to products with warranties not in conflict with requirements of the Contract Documents.
- F. The Owner reserves the right to refuse to accept Work for the Project where a special warranty, certification, or similar commitment is required on such Work or part of the Work, until evidence is presented that entities required to countersign such commitments are willing to do so.
- G. Disclaimers and Limitations: Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the Work that incorporates the products, nor does it relieve suppliers, manufacturers, and subcontractors required to countersign special warranties with the Contractor.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 02 32 14

VIBRATION MONITORING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide vibration monitoring as indicated and in compliance with Contract Documents.
 - 1. Furnish, install, maintain, monitor, and remove vibration monitoring equipment as specified and as indicated.
 - 2. Monitor vibrations, air blast overpressures and noise levels originating from construction operations as indicated or specified.
 - 3. Modify construction operation procedures if existing operation creates vibration, air blast overpressure, or noise exceeding specified amounts.
 - 4. Vibration monitoring for blasting shall conform to the requirements of this specification section and the requirements of all applicable Local and State Authorities.

1.02 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 43 00.
- B. Retain the services of an independent vibration consulting firm with the following in-house personnel to conduct the following vibration monitoring requirements:
 - 1. Preparation, signing and stamping of monitoring plans and daily reports, and overseeing monitoring and interpretation of monitoring equipment shall be performed by personnel with the following qualifications:
 - a. Be a State of Utah Registered Professional Engineer.
 - b. Have a minimum of 5 years' experience in the vibration consulting field.
 - c. Have successfully completed at least 5 projects with vibration-inducing operations, air blast overpressures, and noise levels equal to or more severe than those to be encountered.
 - 2. Installation, monitoring and interpretation of monitoring equipment shall be performed by personnel with the following qualifications:
 - a. Have at least 3 years' experience in the operation of monitoring equipment proposed for use and interpretation of records produced by such equipment.

- b. Have installed, operated, monitored and interpreted equipment and records on at least 3 projects with vibration-inducing operations, air blast overpressures, and noise levels from similar construction activities.
- 3. Performed and maintained calibration records on all instruments used to monitor the blasting program.

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

- 1. Qualifications of the independent vibration consulting firm's Professional Engineer as specified in subparagraph 1.02.B.1 including the names of the 5 successful projects with names, current addresses, and telephone numbers of persons in charge of representing the owners or the owners at the time of monitored vibration-inducing operation, air blast overpressures, and noise levels.
- 2. Qualifications of the vibration consulting firm's personnel to install, operate and interpret the monitoring equipment as specified in subparagraph 1.02.B.2 including the name of the personnel and the names of the 3 projects per person which they installed, operated, monitored, and interpreted monitoring equipment with names, current addresses and telephone numbers of persons in charge of representing the owners or the owners at the time of monitored vibration-inducing operations, air blast overpressures, and noise levels.
- 3. Two weeks prior to commencement of blasting or other vibration inducing operations, submit in writing the plan for monitoring operations and equipment to be used to assure compliance with the vibration, air blast overpressure, and noise limitation. As a minimum, this plan shall provide for the following:
 - a. Recommended vibration limiting methods to meet the specified peak particle velocity limitations and locations for taking measurements.
 - b. Manufacturer's brochures and written operation instructions for seismograph recording equipment intended to be used for each vibration occurrence.
- 4. Daily reports, while blasting or performing other vibration-inducing operations, detailing each source of vibration, location of monitoring, and the vibration records highlighting peak particle velocities. For blasting, include the air blast overpressure records as well as a plot of particle velocity versus scaled distance. All daily reports shall be stamped and signed by the Vibration Consulting Firm's Professional Engineer.

PART 2 - PRODUCTS

2.01 EQUIPMENT:

- A. Provide a low frequency sensitive three-component seismic recording instrument with wave paper trace, variable trigger level setting, peak particle velocity memory operation (in inches/second) and air blast overpressure and sound level readout capability that meets the following criteria:
 - 1. Seismic Frequency Range: 2 to 200 Hertz (plus or minus 3 dB)
 - 2. Acoustic Frequency Range: 2 to 200 Hertz (plus or minus 1 dB)
 - 3. Velocity Range: 0.02 to 4.0 inches per second
 - 4. Sound Range: 90 to 140 dB linear
 - 5. Transducer: Three mutually perpendicular axes: radial, transverse, and vertical
 - 6. Recording: Time-history of waveform capability
- B. Manufacturers:
 - 1. Instantel, Inc., Kanata (Ottawa) Ontario, Canada
 - 2. Slope Indicator Co., Seattle, WA
 - 3. Thomas Instruments, Inc., Spoffard, NH

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Furnish specified instrumentation to be installed, operated and interpreted by the vibration consulting firm's personnel, as specified below and indicated.
- B. Monitor vibrations and record the entire particle velocity wave train, not just peak velocities. Obtain accurate, legible seismometer records of monitored vibrations.
- C. Perform all blasting and other vibration-inducing operations so that vibrations reaching adjacent structures and facilities are within specified limits.
- D. Monitor vibrations by measuring the peak particle velocity in the vicinity of work. Peak particle velocity is defined as a maximum vector sum of three velocity components, measured concurrently in mutually perpendicular directions at any point by an instrument. The peak particle velocity as measured by the vibration consulting firm's personnel on or at the location as specified in the submitted vibration monitoring plan, shall not exceed the limits specified below:

Type of Concrete	Age of Concrete (Hrs)	Peak Particle Velocity In./Sec
Mass Concrete (footings, mats, slab-on-grade, fill concrete, etc.)	0 – 120	0.7
	121 and over	2.0
Concrete Structures (walls, columns, elevated slabs, etc.)	0 – 120	0.7
	120 and over	2.0
Existing Structures, Residences or Utilities		0.5

- E. Air blast over pressures resulting from the blasting shall be recorded. Operate the instruments to make a permanent record for each blast.
- F. In the event any recordings indicate that vibration or air over pressure limits are being exceeded, immediately suspend all blasting and other vibration-inducing operations and submit a report to the Engineer. Revise operations to reduce vibrations and submit a copy of the revised procedure to the Engineer at no additional cost to the Owner.
- G. If evidence of displacement or damage to utilities, equipment, or structures is observed or reported, immediately notify the Engineer and discontinue operations creating the vibrations. Revise operation to reduce vibrations and submit a copy of the revised procedure to the Engineer.
- H. Restore or replace utilities, equipment, or structures damaged by vibrations or air blast overpressures at no additional cost to the Owner.

3.02 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 02 41 00

DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide demolition of existing conditions as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. United States Environmental Protection Agency (USEPA):
 - 1. 832: Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices.

1.03 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 - 1. Demolition Plan.
 - 2. Proposed landfill and/or recycle location(s) for disposal of materials.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Demolition Plan: Provide description of sequence, methods, and equipment used for demolition (including disposal). Include details and schedule to meet requirements for Wildlife Mitigation as shown on General Civil Notes on Drawing 00-C002.

1.05 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 PREPARATION:

A. Survey Markers and Monuments:

1. Provide three reference points, established by a licensed land surveyor, for each survey marker or monument temporarily removed. Record locations and designations of survey markers and monuments prior to removal.
2. Store removed markers and monuments during demolition work and replace upon completion of work. Reestablish survey markers and monuments in conformance with recorded reference points. Forward letter to Engineer, signed by a licensed land surveyor, verifying reestablishment of survey markers and monuments.

B. Burning of demolition debris is prohibited.

C. Protect existing structures, equipment, and appurtenances to remain.

D. Obtain permission from Engineer before abandoning or removing existing structures, materials, equipment, and appurtenances.

E. Maintain circulation of traffic within area at all times during demolition operations.

F. Make necessary arrangements with and perform work required by utility companies and municipal departments for discontinuance or interruption of utility services due to demolition work.

G. Confine apparatus, storage of materials, demolition work, new construction, and operations of workmen to areas that will not interfere with continued use and operation of the adjacent Raintree Apartments. Provide and maintain lights, barriers, and temporary passageways for free and safe access.

H. Provide shoring or bracing where necessary to prevent settlement or displacement of existing or new structures. Do not overload floors.

3.02 DEMOLITION:

A. Demolish and remove existing construction, utilities, equipment, and appurtenances.

B. Provide maximum practicable protection from inclement weather for materials, equipment, and personnel located in partially dismantled structures.

C. Protect persons and property throughout progress of work. Provide safe working conditions for personnel.

D. Wet down work during demolition operations to prevent dust from arising. Minimize spread of dust and airborne particles.

- E. Cap or plug with concrete or non-shrink grout, pipes and other conduits which are abandoned in place.
- F. Removed materials, equipment, and appurtenances, not designated for relocation, become property of Contractor, and shall be disposed of offsite at an approved facility.
- G. Trees, shrubs, and other “green” waste may be disposed off-site at the Provo City Composting Facility located at 1625 S Industrial Parkway.

3.03 SALVAGE:

- A. Store equipment to be salvaged or relocated as directed by Engineer. Protect salvaged items from damage during work.

3.04 REPAIR/RESTORATION:

- A. Repair or remove items that are damaged. Repair and install damaged items to condition at least equal to that which existed prior to start of work.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 01 30
CONCRETE REPAIR

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide concrete repair as indicated and in compliance with Contract Documents.
- B. Complete repair mortar system installation in accordance with these specifications and the mortar system manufacturer's instructions regarding surface preparation, application, inspection and requirements for safety.
- C. Complete crack repair work in accordance with these specifications and crack repair material manufacturer's instructions.
- D. Complete joint repair work in accordance with these specifications and the joint repair material manufacturer's instructions.
- E. The areas of concrete repair shall be determined by the Engineer and shall include any location where acidic attack of the concrete surfaces has reached a depth of 1/2-inch or deeper and at any air voids, bugholes or poorly consolidated concrete areas where the specified filler/surfacer materials cannot be used for filling or surfacing of the concrete.
- F. If repair work is required for an area indicated to receive protective lining or coating, provide such repair in accordance with the requirements of this specification and the related lining specifications.
- G. The repair work specified herein is intended to cover the requirements for repair of concrete only, to a maximum depth of approximately 2-inch. If after blasting and cleaning, an area is discovered that requires a repair greater than 2-inch deep, or an area is discovered that requires repair or replacement of reinforcing steel notify the Engineer so that details may be provided to the Contractor to complete the repair.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 503.4: Standard Specification for Repairing Concrete with Epoxy Mortars
- B. ASTM International (ASTM):
 - 1. C33: Standard Specifications for Concrete Aggregates
 - 2. C150: Standard Specification for Portland Cement

3. C321: Standard Test Method for Bond Strength of Chemical-Resistant Mortars
4. C882: Test Method for Bond Strength of Epoxy Resin Systems
5. D570: Test Method for Water Absorption of Plastics
6. D638: Test Method for Tensile Properties of Plastics
7. D695: Test Method for Compressive Properties of Rigid Plastics
8. D790: Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
9. D4262: L.R. Standard Test Method for pH of Chemically Cleaned or Acid Etched Concrete Surfaces
10. E337: L.R. Standard Practice Test Method for Measuring Humidity with a Psychrometer.

C. National Association of Corrosion Engineers (NACE):

1. 6D-173: "A Manual for Painter Safety"
2. 6F-163: "Surface Preparation of Steel or Concrete Tank Interiors"
3. TPC2: "Coatings and Linings for Immersion Service"

1.03 MEASUREMENT:

- A. Crack Repair: The quantities in linear feet to be measured for payment shall be the actual length of cracks repaired by the methods and materials specified under.
 1. Epoxy crack repair.
 2. Flexible polyurethane crack repair.
 3. Rigid polyurethane crack repair.
- B. Spall Repair Depth 2-inch or Less: The quantities in square feet to be measured for payment shall be the actual square footage of spalled concrete repaired by the method and materials specified under spall repair.
- C. Spall Repair Depth Greater than 2-inch: The quantities in cubic feet to be measured for payment shall be the actual cubic footage of spalled concrete repaired by the method and materials specified under spall repair.
- D. Joint Repair: The quantities in linear feet to be measured for payment shall be the actual length of joints repaired by the methods and materials specified under joint repair.

1.04 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00.

1. Procedures proposed for the accomplishment of repair work. Include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations to be coordinated with other works in progress.
2. Manufacturer's recommendations and product data sheets for all repair materials including performance criteria, surface preparation, ambient condition requirements and applications, curing requirements, volatile organic compound (VOC) data, and safety requirements.
3. Material Safety Data Sheets (MSDS) for any materials brought on-site including all repair system materials, solvents and abrasive blast media.
4. Qualifications of foreman and epoxy gun operators and demonstration of meeting the minimum requirements specified.
5. Design Mixes: Provide concrete and cement mortar in conformance with Section 03 30 00 and as specified herein.
6. ANSI/NSF 61 Certification that repair material proposed for use in structures to contain potable water are non-toxic and have no adverse effect on the quality or appearance of potable water.

1.05 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

B. Furnish the names of all subcontractors proposed for use for this work including necessary evidence and/or experience records to ascertain their qualifications in the application of epoxy, polyurethane polymer-modified and cement-based compounds.

C. Include in accepted applicator qualifications:

1. A minimum of five (5) years' experience in applying epoxy, polyurethane and polymer-modified and cement-based compounds similar to those specified in this Section.
2. A letter from the manufacturer of the specified materials, on the manufacturer's letterhead, signed by an officer of the company, stating that the subcontractor/applicator has been trained in the proper techniques for the preparation of the surface, and proper methods for mixing, placing, curing, and caring of the manufacturer's products. This letter shall further state that the subcontractor/applicator is on the manufacturer's approved list of contractors.

- D. Adhere strictly to the manufacturer's recommendations regarding temperature at time of application for all work. Do not use epoxy materials when either the temperature of the concrete to be repaired or the ambient temperature is below 50 degrees F. 24 hours before, during, or for a period of 48 hours after the completion of the repair. Temporary heat may be used to meet the specified requirements.
- E. Use new epoxy, repair materials and use within the shelf life limitations set forth by the manufacturer. Clearly mark the shelf life limitations of each container.
- F. The Contractor is ultimately responsible for the concrete repair work. Inspections by the Engineer or others do not limit the Contractor's responsibility.
- G. Make all parts of the work accessible for inspections by the Engineer. Correct any conditions not in conformance with the specifications at no additional cost to the Owner.
- H. Provide a Representative on site at all times when work is ongoing to represent the Contractor and to have authority to receive and execute all instructions given by the Engineer.
- I. Allow changes in the specified repair work methods only with the permission of the Engineer.
- J. Provide technical field support or training services required by the accepted material manufacturers at no additional cost to the Owner.
- K. Provide materials from a single manufacturer for all components of a single repair.

1.06 SERVICES OF MANUFACTURERS REPRESENTATIVES:

- A. Provide the services of a qualified manufacturer's technical representative to instruct the Contractor's personnel in the mixing, proper use and application of the epoxy, polyurethane, polymer-modified and cement-based compounds.
- B. Provide written certification from the manufacturers' representative that materials have been mixed and applied properly and surfaces to receive these products have been prepared properly, all in conformance with manufacturer's requirements.
- C. Provide on-site time required for the manufacturer's representative to achieve a successful installation at no additional cost to the Owner.

1.07 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements in Section 01 61 00.
- B. Provide shelter to store materials in area or areas designated by the Owner solely for this purpose. Confine mixing, thinning, clean-up and associated operations and storage of repair mortar materials debris before authorized disposal, to these areas.

- C. Mix all specified materials in the sheltered mixing operation and materials from direct sunlight and inclement weather. Protect facilities from staining and damage.
 - D. Do not dispose of waste materials on-site.
 - E. Store waste temporarily in closed, nonflammable containers until final disposal. Keep no rubbish in Contractor's area longer than 24 hours.
 - F. Deliver all materials to the job site in new, unopened containers. Each container shall bear the manufacturer's name and label. Labels on all material containers shall contain the following information:
 - 1. Name of product.
 - 2. Federal Specification Number if applicable.
 - 3. Manufacturer's batch number.
 - 4. Manufacturer's name.
 - 5. Generic type of material.
 - 6. Hazardous material identification label.
 - 7. Shelf life date.
 - G. Clearly mark all containers indicating any safety hazards associated with the use of or exposure to the materials.
 - H. Handle and store materials to prevent damage or loss of label. Protection of materials is the Contractor's responsibility.
- 1.08 PROJECT/SITE CONDITIONS:
- A. Environmental Requirements:
 - 1. Comply with the repair material manufacturer's recommendations as to environmental conditions under which materials can be applied and cured.
 - 2. Do not apply materials when dust is being generated.
 - B. Protection:
 - 1. Cover or otherwise protect finish work or other surfaces not being repaired.
 - C. Ventilation:
 - 1. Provide ventilation to meet product requirements prior to, during, and after application.

PART 2 - PRODUCTS

2.01 WATER:

- A. The water used for mixing concrete repair products shall be clear, potable and free of deleterious substances.

2.02 AGGREGATE:

- A. All aggregates shall conform to ASTM C33 and Section 03 30 00.

2.03 EPOXY BONDING AGENT:

- A. Epoxy bonding agent shall conform to ASTM C881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives, depending on the application. The class of epoxy bonding agent shall be suitable for all ambient and substrate temperatures.

- B. Products:

1. Sika Corporation; Sikadur 32
2. The Euclid Chemical Company; Duralcrete

2.04 ANTI-CORROSION COATING:

- A. Anti-corrosion coating shall be a three-component, epoxy-modified cementitious material.

- B. Products:

1. Sika Corporation; Sika Armatex 110
2. Sto Concrete Restoration Division; CR 246
3. The Euclid Chemical Company; Duralprep

2.05 EPOXY CRACK REPAIR BINDER:

- A. Epoxy crack repair binder shall be a two-component, 100 percent solids, high-modulus, low viscosity epoxy adhesive suitable for crack grouting by injection.

- B. Products:

1. Sika Corporation; Sikadur 52
2. The Euclid Chemical Company; Duralcrete LV
3. BASF; SBC Concrex 1380

2.06 FLEXIBLE POLYURETHANE CRACK REPAIR MATERIAL:

- A. Flexible polyurethane crack repair material shall be a one-component, water-activated polyurethane hydrophilic injection grout capable of 700 percent expansion. Polyurethane grout shall form a tough flexible foam seal that is impenetrable to water.
- B. Products:
 - 1. Prime Resins; Prime Flex 900 XLV
 - 2. Avanti International; Scotch Seal 5600 Chemical Grout

2.07 RIGID POLYURETHANE CRACK REPAIR MATERIAL:

- A. Rigid polyurethane crack repair material shall be a one-component, water-activated polyurethane hydrophobic injection grout capable of 700 percent expansion. Polyurethane grout shall form a tough rigid foam seal that is impenetrable to water.
- B. Products:
 - 1. De Neef Construction Chemicals; Hydro-Active Cut
 - 2. Prime Resins; Prime Flex 920
 - 3. Sika Corporation; Sikafix HH LV

2.08 EPOXY REPAIR MORTAR:

- A. Epoxy Repair Mortar shall be two-component, 100 percent solids, 100 percent reactive epoxy resin system.
- B. Spall repair mortar for use in horizontal applications.
 - 1. Products:
 - a. BASF; Concreseive Paste LPL
 - b. Sika Corporation; Sikadur 22 Lo-Mod
- C. Spall repair mortar for use in vertical and overhead applications.
 - 1. Products:
 - a. Sika Corporation; Sikadur 23 Lo-Mod Gel

2.09 SPALL REPAIRS USING NON-SHRINK CEMENTITIOUS MORTAR:

A. Products:

1. BASF; EMACO S88 CI
2. BASF; Thorite
3. Sauereisen, Inc.; Underlayment F-120

2.10 SPALL REPAIRS USING POLYMER MODIFIED CEMENTITIOUS MORTAR:

A. Repair spalls repair not requiring formwork using a two-component, polymer-modified cementitious mortar having a minimum 28-day compressive strength of 7,000 psi.

B. Spall repair mortar for use in horizontal applications.

1. Products:

- a. Sika Corporation.; Sikatop 122 Plus
- b. The Euclid Chemical Company; Duraltop Fast Set

C. Spall repair mortar for use in vertical applications.

1. Products:

- a. Sika Corporation; Sikatop 123 Plus
- b. The Euclid Chemical Company; Duraltop Gel

2.11 SPALL REPAIRS REQUIRING FORMWORK:

A. Repair spalls repair requiring formwork using a two-component, polymer-modified cementitious mortar/pea gravel mixture and shall have a minimum 28-day compressive strength of 6,000 psi. Mix each unit of mortar with Saturated Surface Dry (SSD) pea gravel to form the repair material following the manufacturer's recommendations.

B. Products:

1. Sika Corp.; Sikatop 111 Plus
2. The Euclid Chemical Company; Duraltop Flowable Mortar

2.12 WATERPROOF MEMBRANE PATCH:

A. Waterproof membrane patch shall be a hypalon sealing strip secured to the concrete substrate with an epoxy adhesive.

- B. Install sealing system per manufacturer's recommendations.
- C. Products:
 - 1. Sika Corporation; Sikadur Combiflex
- 2.13 CEMENT BASED TEXTURED COATING:
 - A. Products:
 - 1. Sika Corporation; Sikatop 144
 - 2. The Euclid Chemical Company; Duraltop Coating
 - 3. BASF; Thoroseal/Acryl 60
- 2.14 SEALANT:
 - A. Concrete joint sealant shall be a two-component polyurethane sealant as specified in Section 03 15 00. Primers and bond breakers shall conform to the sealant manufacturer's recommendations.
- 2.15 EXPANSION JOINT FILLER:
 - A. Expansion joint filler shall be as specified in Section 03 15 00.
- 2.16 HYDRAULIC CEMENT COMPOUND PATCH AND REPAIR FOR LEAKS:
 - A. Products:
 - 1. Xypex; Patch'N Plug

PART 3 - EXECUTION

- 3.01 GENERAL REQUIREMENTS:
 - A. Perform exterior work during dry weather and appropriate temperature conditions in accordance with the manufacturer's recommendations. Protect unfinished work during inclement weather with tarpulins or heavy gage polyethylene sheeting.
 - B. Perform work in spaces within structures at temperature and conditions suitable for proper curing in accordance with the manufacturer's recommendations.
 - C. Coordinate concrete rehabilitation work with other work being performed.
 - D. Remove scaling, broken, loose and disintegrating materials by use of hand tools or power driven saws, down to solid unyielding material.

- E. Clean surfaces thoroughly of efflorescence, oils, grease and other objectionable material in area to be repaired in accordance with the manufacturer's recommendations.

3.02 EPOXY BONDING AGENT:

- A. Use epoxy bonding agent to adhere fresh mortar to existing concrete. Roughen existing concrete surfaces prior to application of bonding agent. Concrete surface shall be clean and sound, free of all foreign particles and laitance. Place repair material while bonding agent is still tacky or per the written instructions of the manufacturer. Reapply bonding agent if bonding agent cures prior to placement of repair material.
- B. Conform to all the requirements of ACI 503.4, and as specified herein.

3.03 ANTI-CORROSION COATING:

- A. Sandblast, clean and coat reinforcing steel that is cut or exposed during alteration and/or repair operations with an anti-corrosive coating.
- B. Cover all exposed parts of the steel with the coating and apply according to manufacturer's recommendations.

3.04 EPOXY CRACK REPAIR:

- A. Cracks on horizontal surfaces: When permitted by the Engineer, repair existing structural cracks by gravity feeding an epoxy crack repair binder into the prepared crack.
 - 1. Grout concrete surface at the crack to form a minimum 1/4-inch wide by 1/4-inch deep V-notch and clean to remove all loose and foreign particles. Fill crack with clean, dry sand and pour epoxy crack repair binder into V-notch, completely filling crack.
 - 2. As binder penetrates into crack, apply additional binder to the V-notch.
- B. Cracks on vertical or horizontal surfaces: Repair existing structural cracks by pressure injecting an epoxy crack repair binder into the prepared crack per Section 03 64 23. Seal cracked surfaces and install injection ports per manufacturer's recommendations.
 - 1. Do not cut reinforcement steel when drilling holes for injection ports. If rebar is encountered during drilling, abandon the hole and relocate. Patch the abandoned hole immediately with epoxy mortar flush with the surface of the existing concrete.
 - 2. Once the surface sealing material has cured, inject crack with epoxy crack repair binder as directed by the manufacturer.
 - 3. Remove injection ports upon satisfactory completion of crack injection and patch with epoxy mortar.

3.05 RIGID AND FLEXIBLE POLYURETHANE CRACK REPAIR:

- A. Repair leaking cracks by pressure injecting with a waterproof hydrophilic or hydrophobic injection grout seal crack surfaces and install injection ports per manufacturer's recommendations.
- B. Do not cut rebar when drilling holes for injection ports. If rebar is encountered during drilling, abandon the hole and patch immediately with epoxy mortar flush with the surface of the existing concrete.
- C. Once the surface sealing material has cured, inject crack with waterproof hydrophilic or hydrophobic injection grout as directed by the manufacturer.

3.06 SPALL REPAIR:

- A. Saw cut the perimeter of the repair area to a minimum depth of 1/4-inch below the surface of the concrete.
- B. Chip all loose concrete in the repair area to remove loose and degraded concrete to a minimum of 1/4-inch or until a sound substrate is reached.
- C. Clean the area and repair to the original dimensions with spall repair patching material according to the manufacturer's recommendations.
- D. Make final finished surface of patches flat, level and even with the existing concrete surface. Do not feather repair mortar to meet existing concrete surface.
- E. Finish final patches on horizontal surfaces consistent with the finish on the existing structure.

3.07 JOINT REPAIR:

- A. Remove sealant, bond breaker and joint filler.
- B. Remove unsound concrete on the joint faces.
- C. Remove laitance and provide a clean dry surface.
- D. Prepare an epoxy mortar by combining epoxy crack repair binder with aggregate following the manufacturer's instructions.
- E. Restore surface to original dimensions by troweling epoxy mortar onto the existing substrate in a manner to ensure bonding following the manufacturer's instructions.
- F. Cure repair in accordance with the manufacturer's instructions.
- G. Install new joint filler, bond breaker and sealant.

3.08 CEMENT BASED TEXTURED COATING:

- A. Clean existing concrete areas requiring a textured coating and apply the cement based textured coating according to manufacturer's recommendations.
- B. Complete other concrete rehabilitation prior to applying coating.

3.09 PATCH AND REPAIR OF LEAKS USING HYDRAULIC CEMENT COMPOUND:

- A. Prepare surface, mix, and install patch and plug material in accordance with manufacturer's instructions.

3.10 CURING:

- A. Cure repair materials in accordance with manufacturer recommendations.

3.11 CLEANING:

- A. Mechanically remove excess material from walls, floors, etc. after material has cured.
- B. Clean excess materials caused by work under this section from existing surfaces by the use of power sanders. Vacuum surfaces to receive final cleaning and finishing specified under other sections of the specifications. Sand cracks flush to adjacent surfaces.
- C. Remove misplaced sealants using methods and materials recommended by the manufacturers. Leave finished work and work area in a neat and clean condition.

3.12 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 05 10

LEAKAGE TESTING OF CONTAINMENT STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section describes the method of testing concrete containment structures for leakage. All containment structures shall be leak tested unless specifically exempted by the Engineer as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 350.1: Tightness Testing of Environmental Engineering Concrete Structures and Commentary.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Provide piping and equipment to test concrete structures for leakage as described herein.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Hydrostatically test reinforced concrete structures which will contain fluids to determine that they conform to leakage criteria specified herein and are free of detectable leaks. Do not hydrostatically test walls that are to be restrained or laterally supported by slabs until slab concrete has obtained the specified compressive strength.
- B. Prior to testing, clean exposed surfaces by thoroughly hosing and removing surface laitance and loose matter from walls and slabs. Remove wash water and debris from the structures by means other than washing through plant piping. All potential leakage points shall be identified and repaired prior to filling the tank with water for the tightness test. Methods for repairing concrete shall be as described in Section 03 01 30.
- C. No backfilling, floor finish, concrete or mortar fill, wall insulation, gasproofing or protective coatings, or permanent pipe connections shall be applied to or installed in any new containment structures until they have been tested for leakage. Testing shall not be done until the concrete has reached its specified design strength.

3.02 LEAK TEST PROCEDURE:

- A. Leakage testing shall meet the provisions of ACI 350.1 – Tightness Testing of Environmental Engineering Concrete Structures. The test criterion shall be HST-NML (no measurable loss) for fully lined prior to tightness test, secondary containment structures; HST-050 (0.050 percent per day) for other tanks as defined by ACI 350.1; HST-100 (0.100 percent per day) for concrete paved reservoirs and channels.
- B. During the test period, the excavation around the structure shall be kept dewatered by the Contractor. Dewatering shall maintain the groundwater level to below the top of the base slab. The Contractor shall temporarily seal all bottom openings and wall openings below maximum water level in the structures, furnish and fill the structures to the design maximum water level with clean water. The Contractor shall make his own arrangements for handling the water for testing and its transfer from one structure to another and its final disposal.
- C. Filling rate shall not exceed 4-feet/24 hours of water depth, or a rate as permitted by the Engineer, with continuous monitoring. Filling shall be at a uniform rate.
- D. During the leakage test period, the Engineer will inspect the structure for leakage or change in volume. If moist spots become visible, indicating the existence of minor leaks, or if the water level indicates hidden leakage, the Contractor shall furnish all materials and do all work necessary to locate the leaks and make the structure watertight to the complete satisfaction of the Engineer. No additional compensation will be allowed for such work.
- E. If, in the opinion of the Engineer, during the course of the test weather conditions are such that it becomes difficult to accurately monitor the water level in the tank, the test shall be stopped, and started over again when weather permits, at no additional cost to the Owner.
- F. On conclusion of the test, the Contractor shall pump or drain the water from the structure and dispose of it without damage to structures or surrounding facilities.
- G. The water tightness test will be considered a pass when no wet spots are observed on the exterior surfaces of the containment structure during the water tightness test period and when the measured loss is less than the maximum specified.

3.03 REPAIR METHODS:

- A. Methods for repairing concrete not passing the leakage test shall be as described in Section 03 01 30.

3.04 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 10 00
CONCRETE FORMWORK

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide design and furnish materials for fabricating, erecting and removing formwork, falsework and shoring for cast-in-place concrete as indicated and in compliance with Contract Documents.
- B. Use formwork to cast all cast-in-place concrete structures with the exception of neat-line dirt excavations and fillets with a dimensional extension to meet 3-inch rebar clearances.
- C. Provide and remove all formwork for electrical work as shown on the drawings or specified under electrical work.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 117/117R: Standard Tolerances for Concrete Construction and Materials.
 - 2. 309.2R: Identification and Control of Visible Effects of Consolidation on Formed Concrete Surfaces.
 - 3. 318/318R: Building Code Requirements for Structural Concrete and Commentary.
 - 4. 347: Guide to Formwork for Concrete.
 - 5. 347.3R: Guide to Formed Concrete Surfaces
- B. Engineered Wood Association (APA)
- C. National Institute of Product Standards and Technology
 - 1. Voluntary Product Standard PS 1 Structural Plywood
- D. National Sanitation Foundation (NSF):
 - 1. 61: Drinking Water System Components – Health Effects

1.03 DESIGN REQUIREMENTS:

- A. Design formwork in conformance with methodology of ACI 347R for anticipated loads, lateral pressures, depth of concrete placement and rate of concrete placement. Design

shall consider any special requirements due to the use of self-consolidating, plasticized and/or retarded set concrete. All forms and shoring shall be designed at the contractor's expense.

1.04 QUALIFICATIONS:

- A. Formwork Designer: Formwork, falsework, and shoring design shall be stamped by an engineer licensed in the State of Utah.

1.05 SUBMITTALS:

- A. Submit product data for form ties, spreaders, chamfer strips, void forms, form coatings, and bond breakers.
- B. Submit following shop drawings in accordance with Section 01 33 00.
 - 1. Layout of panel joints and tie hole pattern. Form Ties-Tapered Through-Bolts: Proposed method of sealing form tie holes.
 - 2. Product data for form ties, spreaders, chamfer strips, and bond breakers.
 - 3. Layout and locations of void forms.
 - 4. ANSI/NSF 61 Certification that form release agents proposed for use in structures to contain potable water are non-toxic and have no adverse effect on the quality or appearance of potable water.

1.06 QUALITY ASSURANCE:

- A. Comply with requirements in Section 01 43 00 and as specified.
- B. Design of Formwork:
 - 1. The Contractor shall assume responsibility for the design, engineering and construction of formwork. Forms shall be designed to produce concrete members identical in shape, lines and dimensions to members shown on the Contract Documents.
 - 2. When high range water reducer (superplasticizer) is used in concrete mix or when self-consolidated concrete is specified, forms shall be designed for full hydrostatic pressure per ACI 347.
 - 3. The formwork shall be designed for the loads and lateral pressures in accordance with ACI 347, ACI 318, and wind loads as specified by the local building code.
 - 4. Construction and contraction joints, openings, offsets, keyways, recesses, moldings, chamfers, blocking, screeds, bulkheads, waterstops, anchorages, inserts, and other features shall be provided.

- 5. Formwork shall be designed to be readily removable without impact, shock, or damage to 'green' concrete surfaces and adjacent materials.
 - 6. The maximum panel deflection shall be $1/360$ of the span between structural members.
 - C. Unless otherwise specified herein, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits as given in ACI 117.
 - D. Materials, fabrications and workmanship found defective shall be promptly removed and replaced and new acceptable work shall be provided in accordance with Contract requirements at no additional cost to the Owner.
- 1.07 DELIVERY, STORAGE AND HANDLING:
- A. Comply with the requirements in Section 01 61 00.
 - B. Materials shall be delivered to the site in an undamaged condition and at such intervals as will avoid delay in the work.
 - C. Material shall be stored and protected in a clean, properly drained location. Material shall be kept off the ground under a weather-tight covering permitting good air circulation. Formwork materials shall be stored on dry wood sleepers, pallets, platforms or other appropriate supports which have slope for positive drainage. Materials shall be protected from distortion, excessive stresses, corrosion and other damage. Materials shall not be stored on the structure in a manner that might cause distortion or damage to the supporting structure.

PART 2 - PRODUCTS

2.01 LUMBER:

- A. Lumber used in form construction shall be Douglas fir, No. 2 grade, S4S, Standard Grading and Dressing Rules No. 16, West Coast Lumber Inspection Bureau; or Southern Yellow Pine, No. 2, S4S, Standard Grade Rules Southern Pine Inspection Bureau. Boards shall be 4 inches or more in width.

2.02 PLYWOOD:

- A. Only grade-marked plywood conforming to APA shall be provided.
- B. Plywood used in form construction shall be Grade B-B, Class 1 plyform, mill-oiled, and sanded on both sides in conformance with U.S. Product Standard PS 1 Structural Plywood.
- C. Thickness shall be sized to maintain alignment and surface smoothness, but not less than 5/8-inch thick.

2.03 STEEL FORMS:

- A. Commercial grade sheets not less than 16 gage shall be provided.
- B. Stock material that is free from warps, bends, kinks, cracks, and rust or other matter that could stain the concrete shall be provided.
- C. Galvanized metal stay in place concrete form system may be used at non-exposed concrete joint surfaces only.
 - 1. Manufacturer:
 - a. AMICO Alabama Metal Industries Corporation, Birmingham, AL Stay-Form

2.04 FORM MATERIAL LOCATIONS:

- A. Wall Forms and Underside of Slabs and Beams:
 - 1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particleboard, or steel in new and undamaged condition, of sufficient strength and surface smoothness to produce specified finish.
- B. Column Forms:
 - 1. Rectangular Columns: As specified for walls.
 - 2. Circular Columns: Fabricated steel or fiber reinforced plastic with bolted together sections or spirally wound laminated fiber form internally treated with release agent for height of column.
- C. Slab-on-grade: Lumber, steel forms or plywood.
- D. All Other Forms: Materials as specified for wall forms.
- E. Rustication Grooves and Chamfer Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.
- F. Chamfer Strips: Wood, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

2.05 FORM TIES:

- A. Locate form ties on exposed surfaces in a uniform pattern. Place form ties so they remain embedded in the concrete except for a removable portion at each end. Form ties shall have conical or spherical type inserts with a maximum diameter of 1 inch. Construct form ties so that no metal is within 1-1/2 inch of the concrete surface when the

forms, inserts, and tie ends are removed. Do not use wire ties. Ties shall withstand all pressures and maintain forms within acceptable deflection limits.

- B. Flat bar ties for panel forms (not permitted for hydraulic structures) shall have plastic or rubber inserts having a minimum depth of 1-1/2 inch and sufficient dimensions to permit patching of the tie hole.
- C. Tapered form ties shall be tapered through-bolts or through-bolts that utilize a removable tapered sleeve.
- D. Wire ties are not permitted.
- E. Water Stop Ties: For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
 - 1. Integral steel water stop 0.103 inch thick and 0.625 inch in diameter tightly and continuously welded to tie.
 - 2. Neoprene water stop 3/16-inch thick and 15/16 inch diameter whose center hole is one-half diameter of tie, or molded plastic water stop of comparable size.
- F. Elastic Vinyl Plug:
 - 1. Design and size of plug shall allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal forming watertight seal.
 - 2. Manufacturer:
 - a. Dayton Superior, Miamisburg, OH; A58 Sure Plug.

2.06 BOND BREAKER:

- A. Bond breaker shall be a V.O.C.-compliant non-staining type that will provide a positive bond prevention.
- B. Manufacturers:
 - 1. Dayton Superior, Sure Lift J6LVOC
 - 2. Nox-Crete, Inc.; Silcoseal Select.

2.07 FORM CAULKING:

- A. Form caulking shall be a one-component, gun-grade silicone sealant that is capable of producing flush, watertight and non-absorbent surfaces and joints. Sealant shall be compatible with the type of forming material and concrete ingredients used.

B. Products:

1. Series 1200 Construction Caulking; GE Silicones, Waterford, NY.
2. Dow Corning 999-A; Dow Corning Co., Midland, MI.

2.08 CHAMFER STRIPS:

- A. Provide 3/4 inch by 3/4-inch chamfer strips milled from clear, straight-grain pine, surfaced each side, or having extruded vinyl type with or without nailing flange unless otherwise shown on the Contract Documents.

2.09 INSERTS:

- A. Provide galvanized cast steel or galvanized welded steel inserts, complete with anchors to concrete and fittings such as bolts, wedges and straps.

2.10 DOVETAIL ANCHOR SLOTS:

- A. Provide dovetail anchor slots manufactured from 22 gage, galvanized steel with removable felt or polyurethane filler shall be provided where specified or shown on the Contract Documents.

2.11 FORM RELEASE AGENT:

- A. Form release agent shall not bond with, stain, or adversely affect concrete surfaces and shall not impair subsequent treatments of concrete surfaces when applied to forms. A ready-to-use water-based material formulated to reduce or eliminate surface imperfections and containing no mineral oil or organic solvents.

- B. Certified as meeting the requirement of ANSI/NSF 61 for contact with potable water.

C. Manufacturers and Products:

1. BASF, Shakopee, MN; MasterFinish RL 211.
2. Cresset Chemical Company; Crete-Lease 20-VOC.
3. Dayton Superior; Farm Fresh XL.

PART 3 - EXECUTION

3.01 FORM TOLERANCES:

- A. Comply with the requirements of ACI 117 for tolerances for formed surfaces except as specified in Table 03 10 00-1.

Table 03 10 00-1	
Vertical alignment (plumbness)	1/4-inch in any 10 feet and 1-inch maximum for entire length
Vertical alignment (BNR Demonstration Facility Structure 3101 only.)	1/4-inch in total length (80 feet) or width (30 feet) of slab on grade.
Variation in the lines and surfaces of foundation mats, base slabs and walls	1/4-inch in any 10 feet and 1-inch max. for entire length
Variation from the level or from the grades indicated on the drawings	1/4-inch in any 10 feet
Variation of the linear building lines from established position in plan	1/2-inch in any 20 feet and 1-inch maximum for entire length
Variation of distance between walls	1/4-inch in any 10 feet and 1-inch maximum for entire length and height
Variation in the sizes and locations of sleeves, floor openings and wall openings	+1/4-inch -1/2-inch
Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	-1/4-inch. +1/2-inch.
Offset between adjacent panels of formwork facing material	1/2-inch (ACI 117 Class C finish).
Offset between adjacent panels of formwork facing material for exposed surfaces where appearance is of importance	1/8-inch (ACI 117 Class A finish).

- B. Tolerances are not cumulative.
- C. Where equipment is to be installed, comply with manufacturer's tolerances if more restrictive than above.
- D. Failure of the forms to produce the specified concrete surface and surface tolerance shall be grounds for rejection of the concrete work. Rejected work shall be repaired or replaced at no additional cost to the Owner.

3.02 PREPARATION:

- A. Clean form surfaces to be in contact with concrete or foreign material prior to installation. Tape, gasket, plug, and/or caulk joints, gaps, and apertures in forms so that the joint will remain watertight and withstand placing pressures without bulging outward or creating surface irregularities.
- B. Coat form surfaces in contact with concrete with a form release agent prior to form installation.
- C. Keep form coatings off steel reinforcement, items to be embedded, and previously placed concrete.

- D. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.
- E. Form liners to be installed for architectural concrete finish shall be in accordance to the manufacturer recommendations.
- F. Void Forms: protect void forms from exposure to moisture and damage prior to installation. See manufacturer recommendations.

3.03 ERECTION AND INSTALLATION:

- A. Forms shall be constructed in accordance with ACI 347 to required dimensions, plumb, straight and mortar tight, and all joints and seams shall be made mortar-tight. Forms shall be substantial, properly braced, and tied together to maintain position and shape and to resist all pressures to which they may be subject. Unless otherwise indicated on the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits in ACI 117 and herein specified.
- B. Provide means for holding adjacent edges and ends of form panels tight and in accurate alignment to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Forms shall be tight and shall prevent the loss of mortar and fines during placing and vibration of concrete.
- C. Provide exterior corners in concrete members with chamfers as specified.
- D. Provide means for removing forms without damage to the surface of finished concrete.
- E. Do not embed any form-tying device or part thereof other than metal in the concrete.
- F. Locate large end of taper tie on the "wet" side of the wall.
- G. Use only form or form-tying methods that do not cause spalling of the concrete upon form stripping or tie removal.
- H. Form surfaces of concrete members except where placement of the concrete against the ground is shown in the drawings or as indicated below. The dimensions of concrete members shown in the drawings apply to formed surfaces, except where otherwise indicated. Placement of concrete against the ground shall be limited to footings.
- I. Openings shall be of sufficient size to permit final alignment of pipes or other items without deflection or offsets of any kind. Allow space for packing where items pass through the wall to ensure watertightness. Provide openings with continuous keyways and water stops. Provide a slight flare to facilitate grouting and the escape of entrained air during grouting. Provide formed openings with additional reinforcement as shown in the typical structural details. Reinforcing shall be at least 2 inches clear from the opening surfaces and encased items.

- J. Set anchor bolts and other embedded items accurately before placing concrete and hold securely in position until the concrete is placed and set. Check special castings, channels, or other metal parts that are to be embedded in the concrete prior to and again after placing concrete. Check nailing blocks, plugs, and strips necessary for the attachment of trim, finish, and similar work prior to placing concrete.

3.04 PROTECTION:

- A. During installation, the forms shall not be used as a storage platform nor as a working platform until the forms have been permanently fastened in position.
- B. Protect void forms from moisture until concrete placement.

3.05 PIPES AND WALL CASTINGS CAST IN CONCRETE:

- A. Install wall spools, wall flanges, and wall anchors before placing concrete. Do not weld, tie, or otherwise connect the wall castings or anchors to the reinforcing steel.
- B. Support pipe and fabricated fittings to be encased in concrete on concrete piers or pedestals. Concrete supports shall transfer loads to firm foundations so that no settlement will occur during construction.
- C. Pipes or wall castings located below operating water level shall have water stop ring collars and shall be cast in place. Pipes fitted with thrust rings shall be cast in place.
- D. Refer to Pipe Penetration Details on Drawings.

3.06 REMOVAL OF FORMS:

- A. Forms shall be removed in accordance with ACI 347 recommendations without damage to concrete and in a manner to ensure complete safety to the structure. Forms, form ties and bracing shall not be removed without specific permission of the Contractor's Registered Professional Engineer.
- B. The following table indicates the minimum allowable time after the last cast concrete is placed before forms, shoring, or wall bracing may be removed; during which the air surrounding the concrete is above 50 degrees F.

Table 03 10 00-2	
Sides of footings and encasements	18 hours
Walls, vertical sides of beams, girders, columns, and similar members not supporting loads	48 hours
Slabs, beams, and girders	48 hours (forms only)
Shoring for slabs, beams, and girders	Until concrete strength reaches specified 28-day strength

Wall bracing	Until top support or roof slab concrete reaches specified 28-day strength
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- C. Form removal and reshoring may be allowed with approval of the Engineer of Record. Removal times will be increased if the concrete temperature following placement is permitted to drop below 50 degrees F.
- D. Do not remove supports and reshore.

3.07 PATCHING OF TAPERED TIE HOLES:

- A. Clear tie hole of all loose debris with a taper tie void brush and flush debris from tie hole with air or water.
- B. Install elastic vinyl plug from larger tie hole end in accordance with manufacturer's instructions using an insertion tool as recommended by the manufacturer.
- C. Coat entire annular surface of the hole with epoxy bonding compound prior to filling with non-shrink, non-metallic patching mortar. Apply epoxy in accordance with manufacturer's instructions.
- D. Fill each side of hole with mortar. Apply mortar to the "wet" side of the wall first. Consolidate mortar solidly into the hole.

3.08 ALUMINUM SURFACES IN CONTACT WITH CONCRETE:

- A. Coat aluminum surfaces that will be in contact with concrete per Section 09 96 00.

3.09 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 15 00

CONCRETE JOINTS AND ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section describes materials, testing, and installation of concrete joints and accessories as specified and as shown on contract drawings.

1.02 REFERENCES:

- A. ASTM International (ASTM):

1. A276: Standard Specification for Stainless Steel Bars and Shapes.
2. C920: Specification for Elastomeric Joint Sealants
3. C1193: Guide for Use of Joint Sealants
4. D412: Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension.
5. D570: Standard Test Method for Water Absorption of Plastics
6. D624: Standard Test method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
7. D638: Standard Test Method for Tensile Properties of Plastics
8. D746: Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
9. D747: Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
10. D792: Standard Test Methods for Density and Specific Gravity of Plastics by Displacement.
11. D994: Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
12. D1171: Standard Test Method for Rubber Deterioration – Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
13. D1259: Standard Test Methods for Nonvolatile Content of Resin Solutions.

14. D1752: Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

15. D2240: Standard Test Method for Rubber Property – Durometer Hardness

B. National Sanitation Foundation (NSF):

1. 61: Drinking Water System Components – Health Effects

C. Environmental Protection Agency (EPA):

1. 40 CFR 59: National Volatile Organic Compound Emission Standards for Consumer and Commercial Products.

D. Corps of Engineers:

1. CRD-C 572: Specifications for Polyvinylchloride Waterstop.

E. Federal Specifications:

1. TT-S-00230C: Sealing Compound: Elastomeric Type, Single Component

F. National Sanitation Foundation (NSF):

1. 61: Drinking Water System Components – Health Effect

1.03 SUBMITTALS:

A. Submit following shop drawings in accordance with Section 01 33 00.

1. Manufacturer's printed data and application instructions for specified materials and locations where materials are to be used.

2. Submit material one samples of each type of water stops.

3. Submit layouts for joints for approval by Engineer of Record (EOR).

4. Certification that materials used within the joint system are compatible with each other.

5. For potable water, provide certification that joint materials meet the requirements of ANSI/NSF 61 for contact with potable water.

1.04 QUALITY ASSURANCE:

A. Comply with requirements in Section 01 43 00 and as specified.

B. Do not add, relocate or omit joints without written permission from the Engineer.

- C. Reject material exceeding expiration date for use.
- D. Clean concrete surfaces to receive expansion joint compound in accordance with the printed instructions of the joint compound manufacturer.
- E. In structures to contain potable water, use joint materials that are ANSI/NSF 61 approved for contact with potable water.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements in Section 01 61 00.
- B. Transport, handle and deliver materials to the job site in the manufacturer's sealed bags, unopened containers or banded pallets.
- C. Store materials off the ground on a platform or skids and protect with covers from snow, rain and ground splatter.
- D. Store expansion joint compounds in a dry location where they cannot freeze.
- E. Store plastic products under cover in a dry location, out of direct sunlight.

1.06 MANUFACTURER'S SERVICES:

- A. Prior to joint preparation for joints receiving sealant materials, require joint manufacturer's technical representative to demonstrate, on site, joint preparation, priming, and sealant materials application for the Contractor's personnel performing joint work.

PART 2 - PRODUCTS

2.01 PVC WATERSTOP:

- A. Waterstops shall be extruded from a PVC compound and shall be lock-rib, center-bulb, retro-fit or flat-strip type as indicated in the Contract Drawings. Water stop shall comply with Corps of Engineers Specification CRD-C-572.
- B. PVC waterstops for construction joints: flat ribbed type, 6 inches wide unless otherwise noted on the Contract Drawings, with a minimum thickness of 3/8-inches.

1. Products:

- a. Sika Greenstreak; Model 679
- b. BoMetals, Inc.; Model FR-638
- c. Vinylex; Model R638

- C. PVC waterstop for contraction joints shall be ribbed with a center bulb, 6 inches wide with a minimum thickness of 3/8-inches. The center bulb shall have an O.D. not less than 7/8-inches.
1. Products:
 - a. Sika Greenstreak; Model 732
 - b. BoMetals, Inc.; Model RCB-638LB
 - c. Vinylex; Model RB638H
- D. PVC waterstop for expansion joints shall be ribbed with a center bulb, 9 inches wide with a minimum thickness of 3/8-inches . The center bulb shall have an O.D. not less than 1-3/8 inches.
1. Products:
 - a. Sika Greenstreak; Model 738
 - b. BoMetals, Inc.; Model RCB-938VLB
 - c. Vinylex; Model RB938H
- E. PVC waterstops for sealing existing concrete structures and new concrete placement shall be retro-fit type, 6 inches wide and 3-3/16 inches height with a minimum thickness of 3/8-inches. Attach waterstop to existing concrete using 1/4-inch by 2-1/4 inch stainless steel sleeve expansion bolt with stainless steel batten bars.
1. Products:
 - a. Sika Greenstreak; Model 609
 - b. BoMetals, Inc.; Model RF-638
- F. Provide waterstops resistant to chemical action with Portland cement, alkalies, acids, and not affected by mildew or fungi. It shall show no effect when immersed for 10 days in a 10 percent solution of sulfuric or hydrochloric acid, saturated lime solution or salt water. Water stops shall be such that any cross section will be dense, homogeneous, and free from porosity and other imperfections. They shall be symmetrical in shape. When tested in accordance with Federal Standard No. 601, the material shall meet the requirements in Table 03 15 00-1.

Table 03 15 00-1	
Requirement	ASTM Spec.
Tensile strength, 2,000 psi	D638
Hardness, Shore durometer, 60-70	D2240
Elongation, ultimate, 280	D638

Table 03 15 00-1	
Requirement	ASTM Spec.
Water absorption, dry weight, maximum (48 hours) 0.32 percent	D570
Specific gravity, 1.3	D792
Stiffness in flexure, 920 psi	D747
Cold brittleness, -35 degrees F	D746
Tear resistance, 290 lbs/inch	D624

2.02 HYDROPHILIC RUBBER WATERSTOP:

- A. Provide a bentonite free rubber waterstop. Waterstop shall expand by a minimum of 80 percent of dry volume in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast. Provide minimum concrete cover as recommended by the waterstop manufacturer.

1. Products:

- a. Adeka; Ultraseal MC-2010MN
- b. Sika; Hydrotite

2.03 ELASTOMERIC JOINT SEALANT:

- A. Federal Specification TT-S-00230C Type 1, Class A, single component, cold applied, pourable, polyurethane.

1. Products:

- a. The Euclid Chemical Company; Eucolastic 1
- b. Tremco; Vulkem 45SSL

2.04 JOINT SEALANT FOR CONCRETE STRUCTURES:

- A. Joint sealant shall be a multipart, gray, non-staining, non-sagging, gun grade polyurethane sealant, which cures at ambient temperature to a firm, flexible, resilient, tear-resistant rubber. Sealant shall comply with ASTM C920, Type M, Grade P, Class 25 for horizontal joints and Grade NS, Class 25 for vertical joints and be recommended by the manufacturer for continuous immersion in water. Troweling of sealants into joints will not be permitted. Sealant shall meet requirements in Table 03 15 00-2.

Table 03 15 00-2	
Characteristic or Parameter	Technical Requirements
Pot life	1 to 3 hours
Hardness	35 Shore A, +/- 5
Elongation	650 percent, ASTM D412
Tensile strength	200 psi, ASTM D412

Table 03 15 00-2	
Characteristic or Parameter	Technical Requirements
Peel strength on concrete	No adhesion loss at 25 pounds
Temperature service range	40 to 167 degrees F
Immersion in water	Continuous

B. Products:

1. Tremco; Vulkem 227 or Vulkem 245 (for Type M, Grade P, Class 25)
2. Sika Corporation; Sikaflex-2CNS (for Grade NS, Class 25), Sikaflex-2CSL

C. For submerged applications, use multi-component chemical resistant polysulfide sealant conforming to ASTM C920, Type M, Grade NS, Class 25.

1. BASF; Sonolastic Two-part
2. The Euclid Chemical Company; Tammsflex NS

2.05 EPOXY JOINT SEALANT:

A. 100 percent solids per ASTM D1259, two-part epoxy with an instantaneous Shore D hardness of 50 to 65 per ASTM D2240.

1. Metzger-McGuire Co.; MM80 or Edge Pro50
2. The Euclid Chemical Company; Euco700

2.06 BACKING ROD FOR EXPANSION JOINTS:

A. Provide an extruded closed-cell polyethylene foam rod. The rod shall be 1/4-inch larger in diameter than the joint width. Where possible, provide full-length sections for the joint; minimize splices.

1. Industrial Systems Department; Minicel backer rod
2. Hercules, Inc.; Plastic Products Group

2.07 BOND BREAKER TAPE:

A. Provide an adhesive-backed glazed butyl or polyethylene tape that will adhere to the premolded joint material or concrete surface. The tape shall be the same width as the joint. The tape shall be compatible with the sealant.

2.08 PREMOLDED JOINT FILLER FOR PAVEMENTS AND SLABS:

A. Joint filler shall be pre-formed, non-extruded type constructed of closed-cell neoprene conforming to ASTM D1752, Type I.

- B. Bituminous-type preformed expansion joint filler conforming to ASTM D994.
- 2.09 PREMOLDED JOINT FILLER FOR LIQUID CONTAINMENT STRUCTURES:
 - A. Self-expanding cork per ASTM D1752, Type III.
 - B. Sponge Rubber per ASTM D1752, Type I. Preformed, non-extruded type constructed of closed-cell neoprene.
- 2.10 BOND BREAKER FOR JOINT COMPOUNDS:
 - A. Provide polyethylene tape.

PART 3 - EXECUTION

- 3.01 PVC WATERSTOPS:
 - A. Heat splice at ends and intersections. Provide waterstops that provide a continuous, uninterrupted watertight diaphragm throughout the entire joint system below the high water level and below grade.
 - B. Construct forms for construction joints to prevent injury to water stops. Hold water stops securely in position in the construction joints by wire ties, continuous bars, and rings as shown on contract drawings. Install water stops in construction, contraction and expansion joints in liquid containment structures and shown on contract drawings.
 - C. Use factory-made crosses, tees and ells. Make field splices with a thermostatically controlled heating iron in conformance with the manufacturer's current recommendations. Allow at least 10 minutes before pulling or straining the new splice in any way. The finished splices shall provide a cross section that is dense and free of porosity with tensile strength of not less than 80 percent of the unspliced materials.
 - D. Provide waterstops with an integral fastening system consisting of grommets or pre-punched holes.
- 3.02 JOINTS:
 - A. Make joints only at locations shown on the contract drawings or as permitted by the Engineer. Any addition or relocation of construction joints proposed by the Contractor, must be submitted to the Engineer for written permission.
 - B. Relocate additional joints where they least impair strength of the member. In general, locate joints within the middle third of spans of slabs, beams and girders. If a beam intersects a girder at the joint, offset the joint a distance equal to twice the width of the member being connected. Locate joints in walls and columns at the underside of floors, slabs, beams or girders and at tops of footing or floor slabs.

- C. Cast structural slabs and beams monolithically without horizontal joints unless specifically indicated on the drawings.
- D. Do not use horizontal joints within foundation mats, base slabs, footings, pile caps, slabs on grade or elevated beams and slabs.
- E. Provide joints in concrete fills and toppings at the same location as the joints in the supporting concrete.
- F. Provide waterstops in all wall and slab joints in liquid containment structures and at locations shown on the contract Drawings. Do not provide metal waterstops unless permitted by Engineer.
- G. Construction Joints:
 - 1. Provide flat ribbed waterstops at construction joints where shown on contract drawings and specified herein.
 - 2. Allow 48 hours between pours of adjacent slabs.
 - 3. Where joint key ways are shown on contract drawings form keyways by beveled strips or boards placed at right angles to the formed face. Except where otherwise shown on contract drawings or specified, keyways shall be at least 1-1/2 inches in depth over at least 25 percent of the width of the section.
 - 4. After the pour has been completed to the construction joint and the concrete has hardened, thoroughly clean the entire surface of the joint of surface laitance, loose concrete, foreign material, and expose clean aggregate by sandblasting or waterblasting the surface of construction joints before placing the new concrete. Care shall be taken to protect any exposed joint material, such as PVC waterstops.
 - 5. In case of emergency, place additional construction joints. (An interval of 45 minutes between two consecutive batches of concrete shall constitute cause for an emergency construction joint.)
- H. Contraction Joints:
 - 1. Provide center-bulb waterstop at contraction joints where shown on contract drawings and specified herein.
 - 2. Where specifically noted on the Drawings, coat the concrete surface with a bond breaker prior to placing new concrete against it. Avoid coating reinforcement or waterstops with bond breaker at these locations.

3. Full Contraction Joints:

- a. Do not extend reinforcement or other embedded items bonded to the concrete (except dowels bonded on only one side of joint) continuously through any expansion joint.
- b. Where shown on contract drawings provide stainless steel expansion joint dowels. Secure tightly stainless steel expansion joints in forms with rigid ties. Orient dowels to permit joint movement.

4. Partial Contraction Joints:

- a. Extend every other bar of reinforcement steel through partial contraction joints or as indicated on the drawings.

I. Control Joints:

1. Do not use control joints in liquid containing structures unless specifically indicated on the Contract Drawings.
2. Locate control joints as shown on the Contract Drawings.
3. Form control joints with control joint inserts or sawcuts.
4. For sawcutting:
 - a. Using early entry saws, saw joints in slabs before the formation of uncontrolled cracking (i.e., cracking that occurs at locations other than construction, control, or contraction joints) and as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing.
 - b. Fill saw cut to full depth with elastomeric joint sealant for joints not exposed to vehicular traffic. Fill joints to full depth with epoxy joint sealant for joints exposed to vehicular traffic.
5. Unless noted otherwise on the Contract Drawings, total reduction in concrete member thickness shall be at least 1/4 the member thickness.

3.03 INSTALLATION OF JOINT SEALANTS:

- A. Immediately before installing the joint sealant, clean the joint cavity by sandblasting or power wire brushing. Install bond breaker tape per manufacturer's instructions.
- B. Apply masking tape along the edges of the exposed surface of the exposed joints.
- C. Application criteria for the sealant materials, such as temperature and moisture requirements and primer cure time, shall be in accordance with the recommendations of the sealant manufacturer.

- D. After the joints have been prepared as described above, apply the joint sealant. Apply the primer, if required, and joint sealant only with the equipment and methods recommended by the joint sealant manufacturer.
- E. Trowel the joints smooth with a tuck pointing tool wiped with a solvent recommended by the sealant manufacturer.
- F. After the sealant has been applied, remove the masking tape and any sealant spillage.
- G. Sealants used in water retaining structures shall achieve final cure at least seven days before the structure is filled with water.

3.04 LEAKAGE TESTING:

- A. Test hydraulic structures in accordance with Section 03 05 10.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 15 20

ANCHORAGE IN CONCRETE AND MASONRY

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide specified anchor bolts complete with washers and nuts as indicated and in compliance with Contract Documents. Unless otherwise specified, anchor bolts shall be hot-dip galvanized or Type 304 or 316 stainless steel.

1.02 SPECIAL INSPECTION:

- A. Special inspection of anchor bolts shall be performed by the Special Inspector and in accordance with the IBC and the Statement of Special Inspections.

1.03 REFERENCES:

- A. American Concrete Institute (ACI):

- 1. 318: Building Code Requirements for Structural Concrete, and Commentary

- B. ASTM International (ASTM):

- 1. A36: Structural Steel
 - 2. A108: Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
 - 3. A123: Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
 - 4. A193: Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
 - 5. A194: Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
 - 6. A276: Standard Specification for Stainless Steel Bars and Shapes
 - 7. A320: Alloy Steel Bolting Materials for Low-Temperature Service
 - 8. A354: Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
 - 9. A449: Quenched and Tempered Steel Bolts and Studs

10. A490: Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
11. A493: Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging
12. A563: Standard Specification for Carbon and Alloy Steel Nuts
13. A572: Standard Specification for High Strength Low Alloy Columbium Vanadium Structural Steel
14. F593: Stainless Steel Bolts, Hex Cap Screws and Studs
15. F594: Stainless Steel Nuts
16. F844: Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
17. F1554: Anchor Bolts, Steel, 36, 55, 105-ksi Yield Strength
18. F3125: Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength

C. International Building Code (IBC):

1. International Building Code, 2018 Edition

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.
 1. Data indicating load capacities
 2. Chemical resistance
 3. Temperature limitations
 4. Installation instructions
 5. Manufacturer's data and catalogue numbers
- C. All post installed anchors, adhesive and expansion type anchors shall be listed with at least one of the following agencies, ICC & ICC (ES). Submit ICC evaluation reports for adhesive and expansion type anchors as specified in paragraph 3.02 of this specification section.

- D. Design calculation in accordance with paragraph 2.04 of this specification section.
- 1.05 QUALITY ASSURANCE:
 - A. Comply with the requirements specified in Section 01 43 00.
- 1.06 DELIVERY STORAGE AND HANDLING:
 - A. Comply with the requirements specified in Section 01 61 00.

PART 2 - PRODUCTS

- 2.01 GENERAL:
 - A. Anchor bolt holes in equipment support frames shall not exceed the bolt diameters by more than 25 percent, up to a limiting maximum oversizing of 1/4 inch. Minimum anchor bolt diameter shall be 1/2 inch. Anchor bolts shall be furnished with leveling nuts, the faces of which shall be tightened against flat surfaces as shown to not less than 10 percent of the bolt's safe tensile stress.
 - B. Tapered washers shall be provided where mating surface is not square with the nut.
 - C. Expansion, wedge or adhesive anchors set in holes drilled in the concrete after the concrete is placed will not be permitted in substitution for anchor bolts except where otherwise specified. Upset threads shall not be acceptable.
- 2.02 MATERIALS:
 - A. Anchor bolt materials shall be as specified in Table 03 15 20-1 unless otherwise specified on the contract drawings.
- 2.03 ANTI-SEIZE COMPOUND:
 - A. All stainless steel embedded bolts, expansion anchors, and adhesive anchors shall be assembled with a stainless steel anti-seize compound such as molycote.
- 2.04 DESIGN:
 - A. Anchor bolts for equipment frames and foundations shall be designed in accordance with the IBC. The contractor designed anchor bolts are differed approval, and the "stamped" calculations and drawing shall be submitted to the engineer of record for review of general compliance with design intent. Calculations and shop drawings shall be submitted with the equipment submittal in accordance with the Section 01 33 00 for all anchorage details. All calculations must be made and signed by a civil or structural engineer currently registered in the State of Utah.
 - B. All anchor bolts resisting seismic forces shall be design based on cracked concrete requirement in ACI 318.

Table 03 15 20-1 Anchor Bolt Materials	
Material	Specification
Stainless Steel Anchor Bolts	ASTM A193, Grade B8M Class 1, AISI 316 or ASTM A320, Grade B8M Class 1, AISI 316
Stainless Steel Threaded Rods at Adhesive Anchors	ASTM F593 CW1 (1/4 inches to 5/8 inches Rod) ASTM F593 CW2 (3/4 inches to 1 1/2 inches Rod)
Stainless Steel Nuts and Washers	ASTM A194 Grade 8M, SS316 Nuts with Type 316 SS Washers (ASTM F594 Group 2 Type 316 SS Nuts at Adhesive Anchors)
Carbon Steel Anchor Bolts	ASTM F1554 (Grade 36) – Hot Dip Galvanized unless noted otherwise
High-Strength Carbon Steel Anchor Bolts	ASTM F1554 (Grade 55 Weldable per Supplementary Requirement S1) – Hot Dip Galvanized unless noted otherwise
Carbon Steel Nuts and Washers	ASTM A563 and ASTM F844
Concrete Expansion Anchors	Stainless Steel HILTI “KWIK BOLT TZ”; SIMPSON STRONG-TIE STRONG BOLT 2
Concrete Adhesive Anchoring System	HILTI HIT-HY 200; SIMPSON STRONG-TIE SET-XP
Stainless Steel Headed Anchor Studs	ASTM A276 or A493; Nelson Stud Welding, Inc.
Carbon Steel Headed Anchor Studs	ASTM A108; Nelson Stud Welding, Inc.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Fieldwork, including cutting and threading, shall not be permitted on galvanized items. Dissimilar metals shall be protected from galvanic corrosion by means of pressure tapes, coatings or isolators. Grouting of anchor bolts with non-shrink or epoxy grouts, where specified, shall be in accordance with Section 03 60 00. All stainless steel anchor bolts and fasteners shall be assembled with stainless steel anti-seize compound.

3.02 INSTALLATION:

A. Cast-In-Place Anchor Bolts:

1. Anchor bolts to be embedded in concrete shall be placed accurately and held in correct position while the concrete is placed. Only where specifically shown on the contract plans recesses or blockouts shall be formed in the concrete and the metalwork shall be grouted in place in accordance with Section 03 60 00 after strength is attained. The surfaces of metalwork in contact with concrete shall be thoroughly cleaned.
2. After anchor bolts have been embedded, their threads shall be protected by grease and the nuts run on.
3. For grouting of anchor bolts, use non-shrink, non-metallic grout as specified in Section 03 60 00.

B. Adhesive Anchors:

1. Use of adhesive or capsule anchors shall be as shown on the contract drawings and shall be subject to the following conditions:
 - a. Use shall be limited to locations where exposure, on an intermittent or continuous basis, to acid concentrations higher than 10 percent, to chlorine gas, or to machine or diesel oils, is extremely unlikely.
 - b. Use shall be limited to applications where exposure to fire or exposure to concrete or rod temperature above 120 degrees F is extremely unlikely. Overhead applications (such as pipe supports), because of the above concerns, shall be disallowed.
 - c. Anchor diameter and grade of steel shall be per contract documents or per equipment supplier specifications. Anchor shall be threaded or deformed full length of embedment and shall be free of rust, scale, grease, and oils.
 - d. Embedment depth shall be as specified on the drawings. Adhesive capsules of different diameters may be used to obtain proper volume for the embedment, but no more than two capsules per anchor may be used. When installing different diameter capsules in the same hole, the larger diameter capsule shall be installed first. Any extension or protrusion of the capsule from the hole is prohibited.
 - e. All installation recommendations by the anchor system manufacturer shall be followed carefully, including, but not limited to, maximum hole diameter, minimum embedment, and minimum edge distance.
 - f. Holes shall have rough surfaces, such as can be achieved using a rotary percussion drill.

- g. Holes shall be blown clean with compressed air and be free of dust or standing water prior to installation.
 - h. Anchor shall be left undisturbed and unloaded for full adhesive curing period.
 - i. Concrete temperature (not air temperature) shall be compatible with curing requirements of adhesives per adhesive manufacturer. Anchors shall not be placed in concrete below 25 degrees F.
- 2. The Contractor shall supply the Engineer with the current ICC evaluation report from the ICC Evaluation Services for the particular brand of adhesive anchors to be used.

3.03 EXPANSION ANCHORS:

- A. Use of expansion anchors shall be as shown on the contract drawings and shall be subject to Conditions c, e, f, g, and h specified in paragraph 3.02-B.1 of this specification section.

3.04 FIELD QUALITY CONTROL:

- A. Testing: 10 percent of each type and size of drilled-in anchor shall be proof loaded by the independent testing laboratory. Adhesive anchors and capsule anchors shall not be torque tested unless otherwise directed by the Engineer. If more than 10 percent of the tested anchors fail to achieve the specified torque or proof load within the limits as defined on the Drawings, all anchors of the same diameter and type as the failed anchor shall be tested, unless otherwise instructed by the Engineer.
 - 1. Tension testing should be performed in accordance with ASTM E488.
 - 2. Torque shall be applied with a calibrated torque wrench.
 - 3. Proof loads shall be applied with a calibrated hydraulic ram. Displacement of adhesive and capsule anchors at proof load shall not exceed $D/10$, where D is the nominal anchor diameter.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 21 00
REINFORCEMENT BARS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Provide concrete reinforcement as indicated and in compliance with Contract Documents:

1. Section Includes:
 - a. Reinforcement bars
 - b. Welded wire reinforcement
 - c. Reinforcement accessories

1.02 REFERENCES:

A. ASTM International (ASTM):

1. A82: Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. A184: Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.
3. A185: Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
4. A496: Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
5. A497: Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete Reinforcement.
6. A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
7. A616: Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement.
8. A617: Standard Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement.
9. A706: Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

10. A767: Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
11. A775: Standard Specification for Epoxy-Coated Reinforcement Steel Bars.
12. A884: Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement.
13. A955: Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement.
14. A1064: Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

B. American Concrete Institute (ACI):

1. 301: Standard Specification for Structural Concrete.
2. 315: Details and Detailing of Concrete Reinforcement.
3. 318: Building Code Requirements for Structural Concrete.
4. 350: Building Code Requirements for Environmental Engineering Concrete Structures
5. SP-66: ACI Detailing Manual.

C. Concrete Reinforcing Steel Institute (CRSI):

1. Manual of Standard Practice.
2. Placing Reinforcing Bars.

D. American Welding Society (AWS):

1. D1.4: Structural Welding Code, Reinforcement Steel.

E. Where reference is made to one of the above standards, the version in effect at the time of bid opening shall apply.

1.03 SUBMITTALS:

A. Unless otherwise acceptable to the Engineer, each submittal shall include reinforcement only for the individual structure to which it pertains.

B. Shop Drawings:

1. Submit bar lists and placing drawings for all reinforced concrete and masonry structures in accordance with Section 01 33 00.

2. Detail reinforcement in conformance with ACI SP-66.
 3. Clearly indicate bar sizes, spacings, locations and quantities of reinforcement steel and wire reinforcement, bending schedules, and supporting and spacing devices. Show joints, with applicable joint reinforcement.
 4. Coordinate bar splicing and placement with Contractor's concrete placing schedule and joint locations. Do not add or delete joints without permission from the Engineer.
 5. Show wall reinforcement in elevation.
 6. Show slab reinforcement in plan view.
 7. Show location and size of all penetrations greater than 12-inches in diameter or least dimension of the opening with the corresponding added reinforcement around the penetrations.
 8. Clearly show marking for each reinforcement item.
 9. Indicate locations of reinforcement bar cut-offs, splices and development lengths.
- C. Submit Certificates: Submit AWS qualification certificates for welders employed on the Work for the appropriate electrode and class of material. Submit certified copies of mill test reports of reinforcement analysis for each shipment of reinforcement with specific lots in shipments identified.
- D. Chemical composition of reinforcement steel: Ladle analysis indicating percentage of carbon, phosphorous, manganese and sulfur present in steel.
- E. Where mechanical couplers are required or permitted to be used to splice reinforcement steel, submit Manufacturer's literature that contains instructions and recommendations for installation for each type of coupler used; certified test reports that verify the load capacity of each type and size of coupler used; and Shop Drawings that show the location of each coupler with details of how they are to be installed in the formwork.
- 1.04 QUALITY ASSURANCE:
- A. Comply with requirements in Section 01 43 00 and as specified.
- B. Do not fabricate reinforcement until shop and placement drawings have been reviewed and accepted by the Engineer.
- C. Perform concrete reinforcement work in accordance with CRSI Manual of Practice, ACI 301, ACI SP-66 and ACI 318.
- D. An independent testing agency shall be retained by the Owner to visually inspect and test reinforcing steel welds in accordance with AWS D1.4.

1.05 QUALIFICATIONS:

- A. Welders: AWS qualified within previous 12 months.

1.06 INSPECTION AND TESTING:

- A. In no case shall any reinforcement steel be covered with concrete until the installation of the reinforcement has been observed by the Engineer and the Engineer's authorization to proceed with the concreting has been obtained. The Engineer shall be given 24 hours minimum prior notice of the readiness of placed reinforcement for observation. The forms shall be kept open until the Engineer has finished observations of the reinforcement steel.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements in Section 01 61 00.
- B. Ship and store reinforcement steel with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings showing the same "mark" designations as those shown on the submitted placing drawings.
- C. Store reinforcement steel off the ground, protected from standing water and kept free from free from mill scale, rust, dirt, grease or other foreign matter.

PART 2 - PRODUCTS

2.01 REINFORCEMENT STEEL:

- A. Reinforcement Steel: ASTM A615, 60 ksi yield grade; deformed billet steel bars, unfinished.
- B. Reinforcement Steel: ASTM A706, 60 ksi yield strength; deformed low-alloy steel bars, unfinished.
- C. Spiral reinforcement shall be cold-drawn steel wire conforming to the requirements of ASTM A82.
- D. Welded Wire Reinforcement:
 - 1. Provide welded wire reinforcement conforming to ASTM A185 in flat sheets.
 - 2. Provide deformed welded wire reinforcement conforming to ASTM A497 in flat sheets.
 - 3. Provide support bars and reinforcement bar supports as specified herein to obtain the concrete cover indicated.

4. Provide welded wire reinforcement heavier than W2.9 in flat sheets.

2.02 ACCESSORY MATERIALS:

- A. Tie Wire: Minimum 16 gage annealed type.
- B. Chairs, Bolsters, Bar Supports, and Spacers: Sized and shaped for strength and support of reinforcement during concrete placement.
- C. Special Chairs, Bolsters, Bar Supports, and Spacers Adjacent to Weather Exposed Concrete Surfaces: Plastic type; size and shape.
- D. Provide 3-inch by 3-inch plain precast concrete blocks, precast concrete doweled blocks or concrete brick for support of bottom reinforcement in foundation mats, base slabs, footings, pile caps, grade beams and slabs on grade. Provide block thickness to produce concrete cover of reinforcement as indicated.
- E. Mechanical Couplers:
 1. Reinforcement Tension Bar Splicers:
 - a. Manufacturers: Cadweld or Lenton rebar splicers by Erico Products, Inc. and Dayton Barsplice, Inc.
 - b. Manufacturers: DB-SAE splicer system by Richmond Screw Anchor Company, Inc., C2D rebar flange coupler by Williams Form Engineering Corporation (special order required) and Lenton Form Saver by Erico Products, Inc.
 - c. Develop minimum 125 percent of yield capacity of bars spliced in tension when tested as assembly in accordance with ASTM A370 and A615.
- F. Reinforcement Compression Bar Splicers:
 1. Manufacturers:
 - a. G-Loc splicers by Gateway Building Products Division
 - b. Speed-Sleeve by Erico Products, Inc.
- G. Provide epoxy for grouting reinforcement bars specifically formulated for such application for the moisture condition, application temperature, and orientation of the hole to be filled.
- H. Epoxy grout shall meet the requirements in Section 03 60 00.

2.03 FABRICATION:

- A. Fabricate concrete reinforcement in accordance with CRSI Manual of Standard Practice.

- B. Weld reinforcement in accordance with AWS D1.4 only when permitted by the Engineer.
- C. Locate reinforcement splices not indicated on Drawings, at point of minimum stress. Review location of splices with Engineer.
- D. Cold bend bars. Do not straighten or rebend bars.
- E. Do not heat reinforcement steel to bend or straighten.
- F. Bend bars around a revolving collar having a diameter of not less than that recommended by the ACI 318.
- G. Cut bar ends that are to be butt spliced or threaded by saw cutting. Terminate such ends in flat surfaces within 1-1/2 degrees of a right angle to the axis of the bar.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Place, support and secure reinforcement against displacement. Do not deviate from required position. Place reinforcement a minimum of 2 inches clear of any metal pipe or fittings.
- B. Position dowels accurately. Rigidly support, align and securely tie dowels normal to the concrete surface before concrete placement. Setting dowels into wet concrete is prohibited.
- C. Position wall dowels projecting from base slabs on grade with templates or guides held in place above the concrete placement line. Position the templates to obtain the required clearance between the dowels and the face of the walls.
- D. Bars additional to those indicated that may be found necessary or desirable by the Contractor for the purpose of securing reinforcement in position shall be provided by the Contractor at no additional cost to the Owner.
- E. Do not extend continuous reinforcement or other fixed metal items through expansion joints. Provide 2 inches clearance from each face of expansion joint.
- F. Provide additional reinforcement bars to support top reinforcement in slabs. Do not shift reinforcement bars from positions in upper layers to positions in lower layers as a substitute for additional support bars.
- G. Support reinforcement steel in accordance with CRSI "Placing Reinforcement Bars" with maximum spacing of 4 feet-0 inches.

- H. Tie reinforcement steel at intersections in accordance with CRSI “Placing Reinforcement Bars”:
1. Maximum tie spacing for footings, walls and columns: every third intersection or 3 feet-0 inches.
 2. Maximum spacing for slabs and other work: every fourth intersection or 3 feet-0 inches.
 3. Tie a minimum of 25 percent of all intersecting bars in foundation mats, base slabs, footings, pile caps, slabs on grade and elevated slabs.
 4. Secure all dowels in place before placing concrete.
 5. Tie wires shall be bent away from the forms and from finished concrete surfaces in order to provide the required concrete coverage.
- I. Locate reinforcement to avoid interference with items drilled in later, such as concrete anchors as identified on the Contract Drawings.
- J. Extend welded wire reinforcement to within 2 inches of edges of slab or section. Lap sheets at least 12 inches or two wire spaces, whichever is greater, at ends and edges and wire tightly together. Stagger end laps.
- K. Unless shown otherwise on Drawings, place welded wire reinforcement in slabs on grade between the upper third point and mid-point of slab. Placing welded wire reinforcement on the subgrade and pulling it up during concrete placement is not permitted.
- L. Support welded wire reinforcement placed over the ground on wired concrete blocks (dobies) spaced not more than 3 feet on centers in any direction.
- M. Support welded wire reinforcement placed over horizontal forms on slab bolsters spaced not more than 30 inches on center.
- N. Mechanical coupler systems may be substituted for dowels at Contractor’s option when permitted by Engineer.
- O. Provide additional reinforcement bars to support ties and stirrups in beams where top reinforcement is not continuous.
- P. Securely support and tie reinforcement steel to prevent movement during concrete placement.
- Q. Ship, handle and place stainless steel reinforcement bars such that they do not come into direct contact with carbon steel. Use stainless steel or non-metallic tie wires and bar chairs. Use nylon, PVC, or polyethylene spacers where stainless steel bar must be attached to carbon steel, to maintain a minimum 1-inch clearance.

- R. Unless otherwise shown on the Drawings or permitted by the Engineer, do not bend reinforcement bars that project from in-place concrete.
- S. Do not weld reinforcement steel bars (including tack welded) either during fabrication or erection unless specifically shown on the Drawings or specified herein, or unless prior written permission has been obtained from the Engineer. Immediately remove bars that have been welded, including tack welds, without such permission from the work. Comply with AWS D1.4 when welding of reinforcement is or called for.
- T. Reinforcement steel interfering with the location of other reinforcement steel, conduits or embedded items may be moved within the specified tolerances or one bar diameter, whichever is greater. Make greater displacement of bars to avoid interference only with the permission of the Engineer. Do not cut reinforcement to install inserts, conduits, mechanical openings or other items without the prior permission from the Engineer.
- U. Reinforcement shall be clean and free from loose mill scale, dirt, grease, oil, form release agent, dried concrete or any material reducing bond with concrete.
- V. Setting bars and welded wire reinforcement on layers of fresh concrete as the work progresses or adjusting reinforcement during the placement of concrete is prohibited.
- W. Provide and place safety caps on all exposed ends of vertical reinforcement that pose a danger to injury or life safety.

3.02 CONCRETE COVER OVER REINFORCEMENT BARS:

- A. Conform to ACI 318 for concrete cover over reinforcement.

3.03 REINFORCEMENT AROUND OPENINGS AND PENETRATIONS:

- A. Accommodate placement of formed openings and penetrations.
- B. Unless specific additional reinforcement around openings and penetrations is shown on the Drawings, provide additional reinforcement steel on each side of opening or penetration equivalent to one half of the cross-sectional area of the reinforcement steel interrupted by an opening or penetration. The bars shall have sufficient length to be fully developed at each end beyond the opening or penetration.
- C. Refer to details on Drawings for additional diagonal bars around openings or penetrations and bar extension length on each side of openings or penetrations.
- D. Where welded wire fabric is used provide extra reinforcement using fabric or deformed bars around opening or penetration.

3.04 SPLICING OF REINFORCEMENT:

- A. Splices may be used to provide continuity due to bar length limitations. Minimum length of bars spliced for this reason is 30 feet. Do not splice reinforcement that is detailed to be continuous in the Drawings.
- B. Stagger bar splices.
- C. Provide tension lap splices at all laps in compliance with ACI 318. Use Class B splices at all locations, unless otherwise noted.
- D. Except as otherwise indicated on the Drawings, stagger splices in circumferential reinforcement in circular walls using Class B tension splices. Do not splice adjacent bars within the required lap length.
- E. Make reinforcement continuous through construction joints.
- F. Reinforcement may be spliced at construction joints provided that entire lap is placed within only one concrete placement.

3.05 ACCESSORIES:

- A. Provide accessories such as chairs, chair bars and the like in sufficient quantities and strength to adequately support the reinforcement and prevent its displacement during the erection of the reinforcement and the placement of concrete.
- B. Use precast concrete blocks where the reinforcement steel is to be supported over soil.
- C. Provide stainless steel bar supports or steel chairs with plastic tips where the chairs are set on forms for a concrete surface that will be exposed to weather, high humidity or liquid (including bottom of slabs over liquid containing areas) unless otherwise noted on contract documents.
- D. Do not use metal chairs, ferrous clips, nails, etc. that extend to the surfaces of the concrete. Do not use stones, brick or wood block supports.
- E. Do not use alternate methods of supporting top steel in slabs, such as steel channels supported on the bottom steel or vertical reinforcement steel fastened to the bottom and top mats unless permitted by the Engineer.
- F. Mechanical Couplers:
 - 1. Couplers that are located at a joint face can be a type that can be set either flush or recessed from the face as indicated.
 - 2. Seal couplers during concrete placement to completely eliminate concrete or cement paste from entering.

3. Recess couplers intended for future connections a minimum of 1/2 inch from the concrete surface. After the concrete is placed, plug the coupler with plastic plugs that have an O-ring seal and the recess filled with sealant to prevent any contact with water or other corrosive materials.
4. Unless indicated otherwise, provide mechanical coupler spacing and size to match the spacing and size of the reinforcement indicated for the adjacent section.

3.06 FIELD QUALITY CONTROL:

- A. Remove reinforcement with kinks or bends not shown on shop or placement drawings. Remove such reinforcement from job site and replace with new fabricated steel. Do not field bend reinforcement unless reinforcement is indicated or specified to be field bent.
- B. Protect reinforcement from rusting, deforming, bending, kinking and other injury. Clean in-place reinforcement that has rusted or been splattered with concrete using sand or water blasting prior to incorporation into the Work.

3.07 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide cast-in-place concrete as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):

1. 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
2. 214R: Recommended Practice for Evaluation of Strength Test Results of Concrete
3. 301: Standard Specifications for Structural Concrete
4. 304R: Guide for Measuring, Mixing, Transporting and Placing Concrete
5. 304.2R: Placing Concrete by Pumping Methods
6. 305R: Hot Weather Concreting
7. 306R: Cold Weather Concreting
8. 308: Standard Practice for Curing Concrete
9. 309R: Guide for Consolidation of Concrete
10. 311.4R: Guide for Concrete Inspection
11. 318: Building Code Requirements for Structural Concrete
12. 347.3R: Guide to Formed Concrete Surfaces
13. 350: Code Requirements For Environmental Engineering Concrete Structures

- B. ASTM International (ASTM):

1. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

3. C31: Standard Practice for Making and Curing Concrete Test Specimens in the Field
4. C33: Standard Specification for Concrete Aggregates
5. C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
6. C40: Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
7. C42: Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
8. C87: Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
9. C88: Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
10. C94: Standard Specification for Ready-Mixed Concrete
11. C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in Cube Specimens)
12. C123: Standard Test Method for Lightweight Particles in Aggregate
13. C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
14. C138: Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
15. C143: Standard Test Method for Slump of Hydraulic Cement Concrete
16. C150: Standard Specification for Portland Cement
17. C157: Standard Test Method for Length Change of Hardened Hydraulic Cement, Mortar and Concrete
18. C171: Standard Specification for Sheet Materials for Curing Concrete
19. C172: Standard Practice for Sampling Freshly Mixed Concrete
20. C192: Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
21. C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
22. C260: Standard Specification for Air-Entraining Admixtures for Concrete

23. C277: Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar Bar Method)
24. C289: Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
25. C295: Standard Guide for Petrographic Examination of Aggregates for Concrete
26. C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
27. C311: Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete
28. C494: Standard Specification for Chemical Admixtures for Concrete
29. C595: Standard Specification for Blended Hydraulic Cements
30. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
31. C881: Standard Test Method for Epoxy Resin Base Bonding Systems for Concrete
32. C882: Standard Test Method for Bond Strength of Epoxy Resin Systems Used with Concrete by Slant Shear
33. C1017: Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
34. C1064: Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete
35. C1077: Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
36. C1107: Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
37. C1116: Standard Specification for Fiber Reinforced Concrete
38. D75: Standard Practice for Sampling Aggregates
39. E154: Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover
40. E1745: Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
41. E329: Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials used in Construction

C. American Association of State Highway and Transportation Officials (AASHTO):

1. M182: Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

D. National Sanitation Foundation (NSF):

1. 61: Drinking Water System Components – Health Effects

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Product Data:

1. Manufacturer's specifications and instructions including Material Safety Data Sheets (MSDS) for admixtures and curing materials. Manufacturer's certification of compatibility of all admixtures.

C. Shop Drawings:

1. Provide certificate that cement used complies with ASTM C595 and these specifications.
2. Provide certificates that aggregates comply with ASTM C33 and contain less than 1 percent asbestos by weight or volume. Submit gradation analysis with concrete mix designs.
3. Provide certificate of compliance with these specifications from the manufacturer of the concrete admixtures.
4. For each formulation of concrete proposed, prepare mix designs in accordance with ACI 318, Chapters 4 and 5, except as modified herein. Submit mix design for review by the Engineer at least 15 days before placing of any concrete.
5. For potable water service, provide certification that materials used in concrete, or the curing and repair of concrete, meet the requirements of ANSI/NSF 61 for contact with potable water.
6. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.
7. Proposed special procedures for protection of concrete under wet weather placement conditions.
8. ACI 301, Section 8 applies for all concrete elements thicker than 48 inches.

9. Provide in mix designs gradation of aggregate. Gradation shall be preformed within 4 months prior to submittal.
 - a. Gradation:
 - (1) List gradings and percent passing through each sieve for coarse, fine, and combined aggregates.
 - (2) Testing shall be performed within 4 months prior to submittal.
 - b. Provide evidence not more than 120 days old showing compliance with the requirements of Article Materials, Paragraph B, including the following:
 - (1) Deleterious substances in fine aggregate per ASTM C33, Table 2.
 - (2) Deleterious substances in coarse aggregate per ASTM C33, Table 4.
 - c. Alkali Aggregate Reactivity: Aggregate shall be classified as non-potentially reactive in accordance with ASTM C33, Table 3 as tested using methods from ASTM C227. Include documentation of test results per applicable standards.
 10. Admixtures: Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.
- D. Informational Submittals:
1. Preinstallation Conference minutes.
 2. Statement of Qualification:
 - a. Batch Plant: Certification under National Ready Mix Concrete Association (NRMCA) Program for Certification of Ready-Mixed Concrete Production Facilities or approved equal.
 - b. Mix designer. NRMCA Concrete Technologist Level 2 or licensed professional engineer.
 - c. Testing agency credentials according to ASTM C1077 and ASTM E329
 - (1) Field tester(s): ACI Concrete Field Testing Technician, Grade 1
 - (2) Laboratory staff: ACI Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I with supervisor being Grade II.
 3. Field test reports.
 4. Recorded temperature data from concrete placement where specified.

5. Concrete Delivery Tickets:

- a. For each batch of concrete before unloading at Site.
- b. In accordance with ASTM C94, including requirements 14.2.1. through 14.2.10.
- c. Indicate amount of mixing water withheld and maximum amount that may be permitted to be added at Site.

E. Test and Evaluation Reports:

1. Provide results of drying shrinkage tests from trial concrete mixes by the Contractor's testing laboratory firm.

F. Manufacturer's Instructions:

1. Provide epoxy bonding compound manufacturer's specific instructions for use. Provide manufacturer's data sheets as to suitability of product to meet job requirements with regard to surface, pot life, set time, vertical or horizontal application, and forming restrictions.

G. Shrink Test Results:

1. Provide shrink test results for Class A2 concrete mixes in accordance with ASTM C157 as modified herein

H. Field Quality Control Submittals:

1. Provide delivery tickets for ready-mix concrete or weighmasters certificate per ASTM C94, including weights of cement and each size aggregate and amount of water added at the plant and record of pours. Record the amount of water added on the job on the delivery ticket. Water added at the plant shall account for moisture in both coarse and fine aggregate.

1.04 SHRINKAGE TESTS:

- A. The testing laboratory shall perform drying shrinkage tests for the trial batches as specified herein.
- B. Fabricate, cure, dry, and measure specimens in accordance with ASTM C157 modified as follows:
 1. Remove specimens from molds at an age of 23 hours plus or minus 1 hour after trial batching, place immediately in water at 70 degrees F, plus or minus 3 degrees F for at least 30 minutes, measure within 30 minutes thereafter to determine original length, and then submerge in saturated lime water at 73 degrees F plus or minus 3 degrees F. At age seven days, make measurement to determine expansion, expressed as a percentage of

original length. This length at age seven days shall be the base length for drying shrinkage calculations (zero days' drying age).

2. Then, store specimens immediately in a humidity-controlled room maintained at 73 degrees F, plus or minus 3 degrees F and 50 percent, plus or minus 4 percent relative humidity for the remainder of the test. Make and report measurements to determine shrinkage expressed as percentage of base length separately for 7, 14, 21, and 28 days of drying after 7 days of moist curing.
 - C. Compute the drying shrinkage deformation of each specimen as the difference between the base length (at zero days' drying age) and the length after drying at each test age. Compute the average drying shrinkage deformation of the specimens to the nearest 0.0001 inch at each test age. If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004 inch, disregard the results obtained from that specimen. Report results of the shrinkage test to the nearest 0.001 percent of shrinkage. Take compression test specimens in each case from the same concrete used for preparing drying shrinkage specimens. These tests shall be considered a part of the normal compression tests for the project.
 - D. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age, shall be 0.036 or 0.042 percent, respectively. Use a mix design for construction that has first met the trial batch shrinkage requirements.
 - E. If the trial batch specimens do not meet the shrinkage requirements, revise the mix design and/or materials and retest.
- 1.05 QUALITY ASSURANCE:
- A. Provide in accordance with Section 01 43 00.
 - B. Unless otherwise indicated, materials, workmanship, and practices shall conform to the following standards:
 1. Local building codes.
 2. ACI 301, "Structural Concrete for Buildings".
 3. ACI 318, "Building Code Requirements for Reinforced Concrete".
 4. ACI 350, "Code Requirements For Environmental Engineering Concrete Structures".
 5. ANSI/NSF 61, "Drinking Water System Components – Health Effects."
 - C. Where provisions of pertinent codes and standards conflict with this specification, the more stringent provisions govern.

- D. Concrete not meeting the minimum specified 28-day design strength shall be cause for rejection and removal from the work.
- E. Perform concrete work in conformance with ACI 301 unless otherwise specified.
- F. Do not use admixtures, including calcium chloride, which will cause accelerated setting of cement in concrete.
- G. Do not place concrete until design mix, material tests and trial concrete batch mix compression test results are accepted by the Engineer.
- H. The Owner shall employ a testing laboratory to test conformity of materials to specifications. Concrete testing shall be performed by an ACI Concrete Field Technician, Grade I or equivalent. Allow free access to obtain test samples.
- I. Methods of Sampling and Testing:
 - 1. Fresh Concrete Sampling: ASTM C172
 - 2. Specimen Preparation: ASTM C31
 - 3. Compressive Strength: ASTM C39
 - 4. Air Content: ASTM C231
 - 5. Slump: ASTM C143
 - 6. Temperature: ASTM C1064
 - 7. Unit Weight: ASTM C138
 - 8. Obtaining Drilled Cores: ASTM C42
 - 9. Drying Shrinkage: ASTM C157
- J. Acceptance of Structure: Acceptance of completed concrete work requires conformance with dimensional tolerances, appearance and strength as indicated or specified.
- K. Hot weather concrete to conform to ACI 305R and as specified herein.
- L. Cold weather concrete to conform to ACI 306R and as specified herein.
- M. Reject concrete delivered to job site that exceeds the time limit or temperature limitations specified. Refer to paragraph 3.02.A for limits.
- N. Do not place concrete in water or on frozen or uncompacted ground.
- O. Workability:

1. Concrete shall be of such consistency and composition that it can be worked readily into the forms and around the reinforcement without excessive vibrating and without permitting the materials to segregate or free water to collect on the surface.
 2. Adjust the proportions to secure a plastic, cohesive mixture, and one that is within the specified slump range.
 3. To avoid unnecessary changes in consistency, obtain the aggregate from a source with uniform quality, moisture content, and grading. Handle materials to minimize variations in moisture content that would interfere with production of concrete of the established degree of uniformity and slump.
- 1.06 DELIVERY, STORAGE, AND HANDLING:
- A. Provide in conformance with Section 01 66 10 and as specified herein.
 - B. Deliver concrete to discharge locations in watertight agitator or mixer trucks without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.
 - C. Reject concrete not conforming to specification, unsuitable for placement, exceeding the time or temperature limitations or not having a complete delivery batch ticket.
- 1.07 SITE CONDITIONS:
- A. Do not place concrete until conditions and facilities for making and curing control test specimens are in compliance with ASTM C31 and as specified herein.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Cement:
 1. Hydraulic Blended Cement, ASTM C595, Type 1L.
 2. Use only one brand of cement in any individual structure. Use no cement that has become damaged, partially set, lumpy, or caked. Reject the entire contents of the sack or container that contains such cement. Use no salvaged or reclaimed cement.
 3. Maximum tricalcium aluminate shall not exceed 8 percent. The maximum percent alkalis shall not exceed 0.6 percent.
- B. Fly Ash:
 1. Provide fly ash conforming to the following requirements:

- a. Class F fly ash conforming to ASTM C618 for chemical and physical properties.
- b. Supplemental requirements in percent:
 - (1) Maximum carbon content: 3 percent
 - (2) Maximum sulfur trioxide (SO₃) content: 4 percent
 - (3) Maximum loss on ignition: 3 percent
 - (4) Maximum water requirement (as a percent of control): 100 percent
 - (5) Fineness, maximum retained on No. 325 sieve: 25 percent
- 2. Fly ash used in concrete that contacts potable water shall be certified as meeting the requirements of ANSI/NSF 61.
- C. Ground Granulated Blast Furnace Slag (GGBF):
 - 1. GGBF, when used, shall meet the requirements of ASTM C989, Grade 100 or better.
 - 2. GGBF used in concrete that contacts potable water shall be certified as meeting the requirements of ANSI/NSF 61.
- D. Silica Fume:
 - 1. The use of silica fume and other natural pozzolans is not permitted.
- E. Fine Aggregates:
 - 1. Clean, sharp, natural sand conforming to requirements of ASTM C33 with a fineness modulus between 2.50 and 3.0.
- F. Coarse Aggregate:
 - 1. Well graded crushed stone, natural rock conforming to requirements of ASTM C33, and shall contain less than 1 percent asbestos by weight or volume.
 - 2. Limit deleterious substances in accordance with ASTM C33, Table 3, Severe Weathering Regions, limit clay lumps not to exceed 1.0 percent by weight, and limit loss when tested for soundness using magnesium sulfate to 12 percent.
- G. Water and Ice:
 - 1. Use water and ice free from injurious amounts of oil, acid, alkali, salt, organic matter or other deleterious substances and conforms to requirements of ASTM C94.

2. Water shall not contain more than 500 mg/L of chlorides nor more than 500 mg/L of sulfate.
 3. Heat or cool water to obtain concrete temperatures specified, and in conformance with ACI 305R and ACI 306R.
- H. Color Additive for Exterior Electrical Duct Encasement:
1. For exterior electrical duct concrete encasements, use a red color additive for identification purposes.
- I. Concrete Admixtures:
1. Maintain compressive strength and maximum water-cement ratios specified in Table 03 30 00-1 when using admixtures. Include admixtures in solution form in the water-cement ratio calculations.
 2. Do not use any admixture that contains chlorides or other corrosive elements in any concrete. Admixtures shall be nontoxic after 30 days.
 3. Use admixtures in compliance with the manufacturer's printed instructions. The manufacturer shall certify the compatibility of multiple admixtures used in the same mix.
 4. Do not use admixtures in greater dosages than recommended by manufacturer.
 5. Air Entrainment:
 - a. Class A concrete; an air-entraining admixture conforming to ASTM C260.
 - b. Products:
 - (1) BASF Corporation; MasterAir AE 90.
 - (2) Sika Corporation; AER-C.
 - c. Adjust the admixture content to accommodate fly ash or pozzolan requirements, and other admixtures when used, in order to obtain the specified air content.
 6. Water Reducing:
 - a. Class A concrete; a water-reducing admixture conforming to ASTM C494, Type A and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
 - b. Products:

- (1) BASF Corporation; Polyheed Series
 - (2) Sika Corporation, Plastocrete 161
 - (3) WR Grace & Co.; Darex II-AEA
 - (4) Euclid Chemical Company; Eucon NW
7. Water Reducing and Retarding:
 - a. Class A concrete; a water-reducing and retarding admixture conforming to ASTM C494, Type D and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
 - b. Products:
 - (1) BASF Corporation; Pozzolith Series
 - (2) Sika Corporation; Plastiment
 - (3) Euclid Chemical company; Eucon WR-91
8. Mid-Range Water-Reducing Admixture (Superplasticizer):
 - a. Class A concrete; a water-reducing and retarding admixture conforming to ASTM C494, Type A and F and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
 - b. Products:
 - (1) BASF Corporation; MasterPolyheed 900
 - (2) Sika Corporation; SikaPlast 200
 - (3) Euclid Chemical company; Eucon MR
9. High-Range Water-Reducing Admixture (Superplasticizer):
 - a. Class A concrete; a High-Range water-reducing admixture conforming to ASTM C494, Type F or ASTM C1017, Type I.
 - b. Products:
 - (1) BASF Corporation; Glenium Series
 - (2) WR Grace & Co.; Daracem 19

(3) Euclid Chemical Company; Eucon SP

10. Shrinkage Reducing Admixture:

- a. Class A concrete; shrinkage-reducing admixture is permitted to be used in the mix to meet shrinkage limitations provided that specified strength are met and there is no reduction in sulfate resistance and no increase in permeability. Quantity of shrinkage-reducing admixture used in the mix shall be added to the quantity of water for purposes of determining the water/cementitious materials ratio.
- b. Products:
 - (1) BASF Corporation; MasterLife SRA 20
 - (2) GCP Applied Technologies; Eclipse
 - (3) The Euclid Chemical Company; Eucon SRA

J. Epoxy Bonding Agent:

- 1. Epoxy bonding agent shall conform to ASTM C881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives. The class of epoxy bonding agent shall be suitable for ambient and substrate temperatures.
- 2. Products:
 - a. Sika Corporation; Sikadur 32, Hi-Mod
 - b. Sika Corporation; Sikadur 32, Hi-Mod LPL
 - c. BASF Corporation, MasterEmaco ADH 326

K. Curing Compound:

- 1. Liquid form, which will form impervious membrane over, exposed surface of concrete when applied to fresh concrete by means of spray gun. Compound shall not inhibit future bond of floor covering or concrete floor treatment. Use Type I-D compound with red fugitive dye, Class B, having 18 percent minimum solids conforming to ASTM C309.
- 2. Provide a copy of manufacturer's certification that the curing compound meets the requirements of ANSI/NSF 61 for concrete surfaces that will be in contact with potable water.
- 3. Products:
 - a. BASF Building Systems; MasterKure 1315WB.

- b. The Euclid Chemical Company; Super Diamond Clear VOX.
- c. W. R. Meadows, Inc.; VOCOMP-30.
- d. Dayton Superior Corp; Cure and Seal 30 percent.

L. Burlap Mats:

- 1. Conform to AASHTO M182.

M. Sisal-Kraft Paper and Polyethylene Sheets for Curing:

- 1. Conform to ASTM C171.

N. Crystalline Waterproofing:

- 1. Provide crystalline waterproofing in all foundation, slabs, and all concrete of water retaining structures; wells, well roof slabs, and below grade structures.
- 2. Cementitious crystalline waterproofing admixture shall be added to concrete at time of batching.
- 3. Products:
 - a. Xypex; Admix C-1000NF, Admix C-2000NF, or Admix C-500

2.02 MIXES:

A. Conform to ASTM C94, except as modified by these specifications.

B. Air content, for Class A shall be as determined by ASTM C231:

- 1. 5 +/- 1-1/2 percent for concrete using 1-1/2 inch maximum aggregate size.
- 2. 6 +/- 1-1/2 percent for concrete using 1-inch maximum aggregate size.
- 3. 6 +/- 1-1/2 percent for concrete using 3/4-inch maximum aggregate size.
- 4. 7 +/- 1-1/2 percent for concrete using 1/2 -inch maximum aggregate size.

C. Provide concrete with the following compressive strengths at 28 days and proportion it for strength and quality requirements in accordance with ACI 318. The resulting mix shall not conflict with limiting values specified in Table 03 30 00-1.

Table 03 30 00-1				
Class	Type of Work	28-Day Minimum Compressive Strength (psi)	Minimum Cementitious Content (lbs per C.Y.)	Maximum Water/ Cement Ratio
A	Concrete for all process and liquid containing structures, concrete grout and concrete not otherwise specified.	4,500	560	0.42
B	Site Pavement, Sidewalks and Curbs	3,000	420	0.45
B-1	Concrete topping over precast and metal deck.	3,000	420	0.45
C	Concrete fill below structure foundations, pipe encasement, miscellaneous unreinforced concrete.	2,000	188	0.60
E	Precast concrete	5,000	560	0.40

D. Measure slump in accordance with ASTM C143:

1. Proportion and produce the concrete to have a maximum slump of 4 inches. Proportion and produce the concrete for filling driven pipe piles to have a slump of 6 inches. A tolerance of up to 1 inch above the indicated maximum is allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.
2. Mixes containing water reducers shall have a maximum slump of 6 inches after the addition of a mid-range water reducer and maximum slump of 8 inches after the addition of a high range water reducer.
3. Mixes containing water reducers shall have a maximum slump of 6 inches after the addition of a mid-range water reducer, and Class A-1 concrete shall have a maximum slump of 9 inches after the addition of a high range water reducer.

E. Pozzolan Content:

1. Fly ash shall not exceed 20 percent of the total cementitious content.
2. Ground Granulated Blast Furnace Slag (GGBF) will be permitted as a substitute for fly ash at no additional cost to the Owner, in the event that Class F Fly Ash is not available. The slag substitution shall be in the same proportions and

percentages of the total cementitious material as shown for fly ash. A higher percentage of GGBF will be allowed if permitted by the Engineer to suit project needs.

F. Aggregate Size:

1. Aggregate size shall be 3/4-inch maximum for slabs and sections 8 inches thick and less. Aggregate size shall be 1 inch maximum for sections greater than 8 inches and less than 17 inches. Aggregate size shall be 1-1/2 inches maximum for all larger slabs and sections. Aggregate size for floor or roof topping slab shall be maximum 3/8-inch.
2. Combined aggregate grading shall be as shown in the following table:

Table 03 30 00-2					
Maximum Aggregate Size	1-1/2 inch	1 inch	3/4-inch	1/2-inch	3/8-inch
Aggregate Grade per ASTM C33	467	57	67	7	8

2.03 CONCRETE TEMPERATURE MONITORING EQUIPMENT:

- A. Equipment used to monitor concrete temperature during the curing period shall consist of electronic equipment capable of continuously monitoring and logging the temperature of the concrete, embedded in the concrete at the locations indicated in the Thermal Control Plan.
- B. As a minimum the equipment shall consist of an enclosed, battery operated logger embedded in the concrete, attached wires extending to and from the surface of the concrete, and a handheld reader that can be attached to the wires and logger data downloaded.
- C. Manufacturers:
 1. IntelliRock System, by Engius.
 2. The Command Center Maturity System, by the Transtec Group, Inc.

PART 3 - EXECUTION

3.01 INSPECTION:

- A. Examine the subgrade and the conditions under which work is to be performed and notify the Engineer in writing of unsatisfactory conditions. Do not proceed with the

work until unsatisfactory conditions are corrected to comply with specified subgrade conditions in a manner acceptable to the Engineer.

3.02 MIXING AND TRANSPORTING CONCRETE:

- A. General: Conform to concreting procedures set forth in ASTM C94, ACI 304R and as specified herein.
1. Transport concrete to discharge locations without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.
 2. Discharge concrete into forms in accordance with Table 03 30 00-3 after cement has entered mixing drum or before the drum has revolved 300 revolutions after the addition of water, whichever occurs first. Do not add water at the jobsite unless permitted by the Engineer. If it is necessary to add water to obtain the specified slump, add water per ASTM C94, but do not exceed the maximum water content in the reviewed concrete design mix. Added water shall be incorporated by additional mixing of at least 35 revolutions.
 3. Do not add water to concrete containing high range water reducing admixture. Do not add water to concrete in delivery equipment not acceptable for mixing.
 4. Keep a record showing time and place of each placement of concrete, together with transit-mix delivery slips certifying the contents of the pour.
 5. Discharge of concrete shall be completed within the limits set out in Table 03 30 00-3.

Table 03 30 00-3	
Maximum Time to Concrete Discharge	
Concrete Temperature	Limit
Over 90 Degree F	Remove concrete from jobsite and discard concrete
86 to 90 Degree F	45 minutes
81 to 85 Degree F	60 minutes
70 to 80 Degree F	75 minutes
Below 70 Degree F	90 minutes

- B. Conveying: Convey concrete from agitator or mixer truck to place of final deposit in forms by one of the following methods:
1. Buckets or hoppers with discharge gates having a clear opening equal to not less than one-third the maximum interior horizontal area or five times the maximum aggregate size being used, whichever is greater, and side slopes of not less than 60 degrees to horizontal.
 2. Buggies or wheelbarrows equipped with pneumatic tires.

3. Round bottom, metal or metal-lined chutes with inclined slope of between 2 to 3 feet horizontally to 1 foot vertically and of sufficient capacity to avoid overflow.
4. Circular drop pipes with a top diameter of at least eight times the maximum aggregate size, but not less than 6 inch, or tapered to not less than six times maximum aggregate size.

3.03 CONCRETE ACCEPTANCE:

- A. Accept or reject each batch of concrete delivered to the point of agitator or mixer truck discharge. Sign delivery batch tickets to indicate concrete acceptance.
- B. Reject concrete delivered without a complete concrete delivery batch ticket as specified herein. The concrete supplier will furnish copies of the signed batch ticket to the Contractor and Engineer.
- C. The testing agency shall perform field tests at the point of agitator or mixer truck discharge. Accept or reject concrete on the basis of conformity with slump, air content and temperature specified.
- D. The testing agency shall inspect concrete transit truck's barrel revolution counter and gauge for measuring water added to the concrete. Reject concrete that exceeds the maximum barrel revolution of 300, the limits in Table 03 30 00-3 or concrete that has water content exceeding the specified water-cement ratio.
- E. Reject concrete not conforming to specification before discharging into the forms.

3.04 VAPOR RETARDER:

- A. Install vapor retarder material under all interior floor slabs on ground whether indicated on the drawings or not.
- B. Install material with 6 in. lap at joints and seal joints with tape as recommended by the vapor retarder manufacturer. Tape material cut for slab penetrations to the pipe, conduit or other items passing through the slab. Use tape recommended by the vapor retarder manufacturer.
- C. Install vapor retarder without punctures or tears and protect against punctures and breaks.

3.05 PREPARATION AND COORDINATION:

- A. Contractor shall notify the Engineer of readiness to place concrete in any portion of the work a minimum of 48 hours prior to concrete placement. Failure to provide this notification will be cause for delay in placing until observations can be completed.
- B. Reinforcement, installation of waterstop, positioning of embedded items, and condition of formwork will be observed by the Engineer prior to concrete placement.

- C. Coordinate the sequence of placement such that construction joints will occur only as designed.
- D. Schedule sufficient equipment for continuous concrete placing. Provide for backup equipment and procedures to be taken in case of an interruption in placing. Provide backup concrete vibrators at the project site. Test concrete vibrators the day before placing concrete.
- E. Compact the subgrade and/or bedding. Saturate the subgrade approximately eight hours before placement and sprinkle ahead of the placement of concrete in areas where vapor barrier is not used. Remove standing water, mud, and foreign matter before concrete is deposited.
- F. Where shown on contract drawings, intentionally roughen surfaces of set concrete in a manner to expose bonded aggregate uniformly at joints.
- G. Where concrete is required to be placed and bonded to existing concrete, coat the contact surfaces with epoxy bonding agent. The method of preparation and application of the bonding agent shall conform to the manufacturer's recommendations.

3.06 CONCRETE PLACEMENT:

- A. Placement shall conform to ACI 304R as modified by these specifications.
- B. Alternate sections of concrete walls and slabs may be cast simultaneously. Do not place adjacent sections of walls and slabs until three days after placement of first placed concrete.
- C. Do not place concrete until free water has been removed or has been diverted by pipes or other means and carried out of the forms, clear of the work. Do not deposit concrete underwater, and do not allow free water to rise on any concrete until the concrete has attained its initial set. Do not permit free or storm water to flow over surfaces of concrete so as to injure the quality or surface finish.
- D. Do not place concrete during inclement weather. Protect concrete placed from inclement weather. Keep sufficient protective covering ready at all times for this purpose.
- E. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing. Do not deposit concrete in large quantities in one place to be worked along the forms with a vibrator.
- F. Deposit concrete in walls and columns continuously and in level layers 4 feet thick. Avoid inclined layers and cold joints. Place concrete at lower portion of slope first on sloping surfaces.
- G. Deposit concrete slab on grade in forms continuously and in level layers 1 to 2 feet thick. Avoid inclined layers and cold joints. Place concrete at lower portion of slope first on sloping surfaces.

- H. Do not deposit partially hardened concrete in forms. Retempering of partially hardened concrete is not permitted. Remove partially hardened concrete from site at no additional compensation.
- I. Do not allow concrete to fall freely in forms to cause segregation (separation of coarse aggregate from mortar). Limit maximum free fall of concrete to 4 feet. Do not move concrete horizontally more than four feet from point of discharge. Space points of deposit not more than eight feet apart.
- J. At least two hours shall elapse after depositing concrete in the columns or walls before depositing in beams, girders, or slabs supported thereon. Place beams, girders, brackets, column capitals, and haunches monolithically as part of the floor or roof system, unless otherwise shown on contract drawings.
- K. Consolidate concrete using mechanical vibrators operated within the mass of concrete and/or on the forms conforming to procedures set forth in ACI 309R and as specified herein.
- L. Conduct vibration to produce concrete of uniform texture and appearance, free of honeycombing, streaking, cold joints or visible lift lines.
- M. Conduct vibration in a systematic manner with regularly maintained vibrators. Furnish sufficient backup units at job site. Use vibrators having minimum frequency of 8,000 vibrations per minute and of sufficient amplitude to consolidate concrete. Use not less than one vibrator with crew for each 35 to 40 cubic yards of concrete placed per hour.
- N. Insert and withdraw vibrator vertically at a uniform spacing over the entire area of placement. Space distances between insertions such that spheres of influence of each insertion overlap.
- O. Use additional vibration with pencil vibrators on vertical surfaces and on exposed concrete to bring full surface of mortar against the forms to eliminate air voids, bug holes and other surface defects. Employ the following additional procedures for vibrating concrete as necessary to maintain proper consolidation of concrete:
 - 1. Reduce distance between internal vibration insertions and increase time for each insertion.
 - 2. Insert vibrator as close to face of form as possible without contacting form or reinforcement.
 - 3. Thoroughly vibrate area immediately adjacent to waterstops without damaging the waterstop.
 - 4. Use spading as a supplement to vibration where particularly difficult conditions exist.

P. Pumping Concrete:

1. Conform to the recommendations of ACI 304.2R except as modified herein.
2. Base pump size on rate of concrete placement, length of delivery pipe or hose, aggregate size, mix proportions, vertical lift, and slump of concrete.
3. Use pipe with inside diameter of at least three times the maximum coarse aggregate size, but not less than 2 inches.
4. Do not use aluminum pipes for delivery of concrete to the forms.

Q. Waterstops:

1. Prevent displacement of waterstops during concrete placement.

3.07 CURING AND PROTECTION:

A. General:

1. Protect concrete from premature drying, hot or cold temperatures, and mechanical injury, beginning immediately after placement and maintain concrete with minimal moisture loss at relatively constant temperature.
2. Comply with curing procedures set forth in ACI 301, ACI 308 and as specified herein.
3. Perform hot weather concreting in conformance with ACI 305R and as specified herein when the ambient atmospheric temperature is 80 degrees F or above.
4. Perform cold weather concreting in conformance with ACI 306R.
5. Concrete required to be moist cured shall remain moist for the entire duration of the cure. Repeated wetting and drying cycles of the curing process will not be allowed.

B. Curing Duration:

1. Start initial curing after placing and finishing concrete as soon as free moisture has disappeared from unformed concrete surfaces. Initial curing starts as soon as concrete achieves final set. Forms left tightly in place are considered as part of the curing system, provided that wooden forms are kept moist by wetting three times a day. Keep continuously moist for not less than 72 hours.
2. Begin final curing procedures immediately following initial curing and before the concrete has dried. Continue final curing for at least 7 days and in accordance with ACI 301 procedures for a total curing period, initial plus final, of at least 10 days.
3. Avoid rapid drying at the end of the final curing period.

C. Curing Requirements:

1. Unformed Surfaces: Protect finished slabs from direct rays of the sun to prevent checking, crazing and plastic shrinkage. Cover and cure entire surface of newly placed concrete immediately after completing finishing operations and water film has evaporated from surface or as soon as marring of concrete will not occur.
2. Formed Surfaces: Minimize moisture loss for formed surfaces exposed to heating by the sun by keeping forms wet until safely removed. Keep surface continuously wet by warm water spray or warm water saturated fabric immediately following form removal unless otherwise permitted by the Engineer.
3. Water Containment Structures: Moist cure by the application of water to maintain the surface in a continually wet condition unless otherwise permitted by the Engineer. Use water that is free of impurities that could etch or discolor exposed concrete surfaces. Other concrete: Moist cure by moisture-retaining cover curing, or the use of curing compound.

D. Curing Methods:

1. Water Curing: Water curing is required for all water retention structures for foundations, floors, and walls. Use water curing for unformed surfaces. Continuously water cure all exposed concrete for the entire curing period. Provide moisture curing by any of the following methods:
 - a. Keeping the surface of the concrete continuously wet by ponding or immersion.
 - b. Continuous water-fog spray or sprinkling.
 - c. Covering the concrete surface with curing mats, thoroughly saturating the mats with water, and keeping the mats continuously wet with sprinklers or porous hoses. Place curing mats to provide coverage of the concrete surfaces and edges, with a 4 inch lap over adjacent mats. Weight down the curing cover to maintain contact with the concrete surface.
2. Sealing Materials:
 - a. Use common sealing materials such as plastic film or waterproofing (Kraft) paper.
 - b. Lap adjacent sheets a minimum of 12 inch. Seal edges with waterproof tape or adhesive. Use sheets of sufficient length to cover sides of concrete member.
 - c. Place sheet materials only on moist concrete surfaces. Wet concrete surface with fine water spray if the surface appears dry before placing sheet material.

- d. The presence of moisture on concrete surfaces at all times during the prescribed curing period is proof of acceptable curing using sheet material.
- 3. Membrane Curing Compound:
 - a. Apply membrane-curing compound uniformly over concrete surface by means of roller or spray at a rate recommended by the curing compound manufacturer, but not less than 1 gallon per 150 square foot of surface area. Agitate curing material in supply container immediately before transfer to distributor and thoroughly agitate it during application for uniform consistency and dispersion of pigment.
 - b. Do not use curing compounds on construction and expansion joints or on surfaces to receive liquid hardener, dustproofer/sealer, concrete paint, tile, concrete fills and toppings or other applications requiring positive bond unless removed by pressure washing or sand blasting.
 - c. Reapply membrane-curing compound to concrete surfaces that have been subjected to wetting within 3 hours after curing compound has been applied by method for initial application.
- E. Protection from environmental conditions: Maintain the concrete temperature above 50 degrees F continuously throughout the curing period. Make arrangements before concrete placing for heating, covering, insulation or housing to maintain the specified temperature and moisture conditions continuously for the curing period.
 - 1. When the atmospheric temperature is 80 degrees F and above, or during other climatic conditions which will cause too rapid drying of the concrete, make arrangements before the start of concrete placing for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or moisture-retaining covering.
 - 2. Protect the concrete continuously for the entire curing period.
 - 3. Maintain concrete temperature as uniformly as possible and protect from rapid atmospheric temperature changes.
 - 4. Avoid temperature changes in concrete that exceed 5 degrees F in any one hour and 50 degrees F in any 24-hour period.
- F. Protection from physical injury: Protect concrete from physical disturbances such as shock and vibration during curing period. Protect finished concrete surfaces from damage by construction equipment, materials, curing procedures and rain or running water. Do not load concrete in such a manner as to overstress concrete.
- G. Protection from Deicing Agents: Do not apply deicing chemicals to concrete.

3.08 FIELD QUALITY CONTROL:

A. Hot Weather Requirements

1. During hot weather, give proper attention to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation in accordance with ACI 305R and the following.
2. When the weather is such that the temperature of the concrete as placed would exceed 90 degrees F, use ice or other means of cooling the concrete during mixing and transportation so that the temperature of the concrete as placed will not exceed 90 degrees F.
3. Take precautions when placing concrete during hot, dry weather to eliminate early setting of concrete. This includes protection of reinforcing from direct sunlight to prevent heating of reinforcing, placing concrete during cooler hours of the day, and the proper and timely application of specified curing methods.

B. Cold Weather Requirements:

1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather in accordance with ACI 306R and the following.
2. When the temperature of the surrounding atmosphere is 40 degrees F or is likely to fall below this temperature, use heated mixing water not to exceed 140 degrees F. Do not allow the heated water to come in contact with the cement before the cement is added to the batch.
3. When placed in the forms during cold weather, maintain concrete temperature at not less than 55 degrees F. Materials shall be free from ice, snow, and frozen lumps before entering the mixer.
4. Maintain the air and the forms in contact with the concrete at temperatures above 40 degrees F for the first five days after placing, and above 35 degrees F for the remainder of the curing period. Provide thermometers to indicate the ambient temperature and the temperature 2 inches inside the concrete surface.

C. Backfill Against Walls:

1. Do not place backfill against walls until the concrete has obtained a compressive strength equal to the specified 28-day compressive strength. Where backfill is to be placed on both sides of the wall, place the backfill uniformly on both sides.
2. Do not backfill the walls of structures that will be laterally restrained or supported by suspended slabs or slabs on grade until the slab is placed and the concrete has reached the specified compressive strength.

D. Concrete Testing:

1. Concrete quality testing will be performed on the concrete by independent testing agency retained by the Owner.
2. The testing agency will use concrete samples provided by the Contractor at the point of agitator or mixer truck discharge to perform slump (per ASTM C143), air content (per ASTM C231), and temperature tests (per ASTM C1064) and for field control test specimens.
3. The testing agency will submit test reports of concrete field measurements specified above to the Contractor and to the Engineer.
4. Provide and maintain facilities for safe storage and proper curing of concrete test specimens on the project site, as required by ASTM C31.
5. Concrete Quality Test Specimen:
 - a. Perform sampling and curing of test specimen in accordance with ASTM C31.
 - b. Testing agency personnel will record truck and load number from the delivery batch ticket, the concrete placement location of each specimen, the date, concrete strength, slump, air content and temperature.
 - c. The testing agency will cast a minimum of one set of 6 test specimens, each 4-inch diameter by 8-inch long cylinders according to the following volumes:
 - (1) when concrete placement in a single day is less than 200 CY: for each 50 cubic yards of each mix design of concrete per structure,
 - (2) when concrete placement in a single day is greater than 200 CY: for each 100 cubic yards of each mix design of concrete per structure,
 - (3) but not less than once a day nor less than once for each 5,000 square feet of surface area of foundation mats, base slabs, columns, walls or elevated slabs and floor beams.
 - d. Test cylinders in accordance with ASTM C39. Test one cylinder at 7 days for information; test three cylinders at 28 days for acceptance; and hold two reserve cylinders for verification. Strength acceptance will be based on the average of the strengths of the three cylinders tested at 28 days. If one cylinder of a 28-day test manifests evidence of improper sampling, molding, or testing, other than low strength, discard it and use a reserve cylinder for the test result.

6. The Contractor may take field control test specimens for small quantities of concrete.
7. Concrete acceptance shall be based on the requirements of ACI 318 and ACI 350.
8. Field cured cylinders conforming to ASTM C31 will be required to determine field compressive strength of concrete. Laboratory cured cylinders for concrete quality testing shall not be used for determining field compressive strength.
9. Concrete Coring:
 - a. When the concrete quality test specimen compression tests fail to be in compliance with the Contract Documents or when the Engineer detects deficiencies in the concrete, the Contractor will take concrete cores at least 2 inches in diameter from the structure in conformance with ASTM C42 at locations determined by the Engineer.
 - b. Obtain at least three representative cores from each member or area of concrete that is considered potentially deficient.
 - c. Obtain additional cores to replace cores that show evidence of having been damaged subsequent to or during removal from the structure.
 - d. The testing agency shall compression test the cores taken from the structure in conformance with ASTM C39 and submit test strength test results of cores specified above to the Contractor and to the Engineer.
 - e. All costs associated with coring and testing of cores will be borne by the Contractor at no additional cost to the Owner.

3.09 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 34 00

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and install Controlled Low Strength Material (CLSM) as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 229R: Controlled Low-Strength Materials
 - 2. 301: Specifications for Structural Concrete
 - 3. 304R: Guide for Measuring, Mixing, Transporting and Placing Concrete
 - 4. 305R: Hot Water Concreting
 - 5. 306R: Cold Water Concreting
 - 6. 308: Standard Practice for Curing Concrete
 - 7. 318: Building Code Requirements for Structural Concrete and Commentary
- B. ASTM International (ASTM):
 - 1. C31: Practice for Making and Curing Concrete Test Specimens in the Field
 - 2. C33: Specification for Concrete Aggregates
 - 3. C39: Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - 4. C94: Standard Specification for Ready-Mixed Concrete
 - 5. C138: Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
 - 6. C143: Standard Test Method for Slump of Hydraulic-Cement Concrete
 - 7. C150: Standard Specification for Portland Cement
 - 8. C172: Practice for Sampling Freshly Mixed Concrete

9. C231: Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
10. C494: Standard Specification for Chemical Admixtures for Concrete
11. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
12. C940: Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
13. C1064: Test Method for Temperature of Freshly Mixed Portland Cement Concrete
14. D75: Practice for Sampling Aggregates

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 1. CLSM mix design and results of strength tests from trial mixes by the Contractor's testing laboratory firm.
 2. Submit manufacturer's Stable-Air Generator Admixture product data, installation instructions and recommendations for material use.
 3. Test and Performance - Submit the following data:
 - a. Any required deviations from prescribed tests and special handling instructions for test specimens.
 - b. Controlled Low Strength Material shall have a minimum strength of 200 psi according to ASTM C39 at 56 days after placement.
 - c. Controlled Low Strength Material shall have minimal subsidence and bleed water which is measured as a final bleeding of less than 2.0 percent (retains 98.0 percent of original height after placement, approximately 1/4-inch per foot of depth) as measured in Section 10 of ASTM C940.
 - d. Controlled Low Strength Material shall have a unit weight of 90 - 110 lbs./ft³ measured at the point of placement.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Do not place CLSM until design mix, material tests and trial batch mix compression test results are approved by the Engineer. Approvals are required at least 30 days before placing any production CLSM.

- C. Employ an independent testing laboratory, acceptable to the Engineer to test conformity of materials to specifications and to design CLSM mixes.
 - D. Furnish, pay for, and deliver representative samples of sufficient quantity of cement, aggregates and admixtures required for trial batch mixes to the testing laboratory. Obtain materials from the batching plant that will be supplying production CLSM in conformance with ASTM D75.
 - E. Measure all materials for CLSM, including water, with equipment and facilities suitable for accurate measurement and capable of being adjusted in conformance with ASTM C94. Use scales certified by local Sealer of Weights and Measures within one year of use and accurate when static load tested to plus or minus 0.4 percent of total capacity of scale. Batch all materials by weight except admixtures that may be batched by volume.
 - F. The testing laboratory will take control test specimens; conduct slump tests and measure air content and temperature in the field.
 - G. Methods of Sampling and Testing:
 - 1. Fresh Concrete Sampling: ASTM C172
 - 2. Specimen Preparation: ASTM C31
 - 3. Compressive Strength: ASTM C39
 - 4. Air Content: ASTM C231
 - 5. Slump: ASTM C143
 - 6. Temperature: ASTM C1064
 - 7. Unit Weight: ASTM C138
- 1.05 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.
 - B. Order CLSM from batching plant so that trucks arrive at discharge locations when material is required.
 - C. Deliver CLSM to discharge locations in watertight agitator or mixer trucks without altering the specified properties of water-cement ratio, slump, air entrainment, temperature, and homogeneity.
 - D. Reject CLSM not conforming to specification, unsuitable for placement, exceeding the time or temperature limitations or not having a complete delivery batch ticket.

1.06 PROJECT/SITE CONDITIONS:

- A. Do not place CLSM until conditions and facilities for making and curing control test specimens are in compliance with ASTM C31 and as specified herein.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Furnish Portland cement conforming to ASTM C150. Use one approved brand from one mill throughout the contract term unless otherwise approved by the Engineer. Use Type II for all work, unless otherwise specified.
- B. Water:
 - 1. Use water that is potable and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances, and conforms to the requirements for water in ASTM C94, and as specified herein.
 - 2. The maximum water-soluble chloride ion in the water shall not exceed 0.060 percent by weight of cement.
- C. Aggregates:
 - 1. Use aggregates for CLSM conforming to ASTM C33 and to the following requirements.
- D. Admixtures:
 - 1. General Requirements: ASTM C494.
- E. Fly Ash: Provide fly ash conforming to the following requirements:
 - 1. Class F fly ash conforming to ASTM C618 for chemical and physical properties.
 - 2. Supplemental requirements in percent:
 - a. Maximum carbon content 3 percent
 - b. Maximum sulfur trioxide (SO₃) content 4 percent
 - c. Maximum loss on ignition 3 percent
 - d. Maximum water requirement (as a percent of control) 100 percent
 - e. Fineness, maximum retained on No. 325 sieve 25 percent

2.02 MIXES:

- A. Mix design shall produce a consistency that will result in a flowable product at the time of placement that does not require manual means to move it into place.
- B. Provide mix with compressive strength of maximum 200 psi when measured 56 days after placement.
- C. Controlled Low Strength Material shall have minimal subsidence and bleed water which is measured as a Final Bleeding of less than 2.0 percent (retains 98.0 percent of original height after placement, approximately 1/4-inch per foot of depth) as measured in Section 10 of ASTM C940 "Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory".
- D. The fresh unit weight shall be 90 - 110 lbs./ft³, except where specified, and in the absence of strength data the cementitious content shall be a maximum of 150 lbs./cy.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Batch, mix and deliver CLSM in conformance with ASTM C94. Batch all constituents at a central batching or mixing plant.
- B. Seasonal Conditions:
 - 1. Conform to ACI 305R and as specified herein for hot weather concreting. Do not add retarder admixture to any concrete.
 - 2. Conform to ACI 306R and as specified herein for cold weather concreting. Do not add accelerator admixture to any concrete.

3.02 TRANSPORTING AND MIXING:

- A. Conform to concreting procedures set forth in ACI 304R and as specified herein.
- B. Transport CLSM to discharge locations without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.

3.03 FIELD TESTING:

- A. General:
 - 1. The testing laboratory will use concrete samples taken at the point of agitator or mixer truck discharge to perform slump, air content, and temperature tests and for field control test specimens.
- B. Notification of Delivery:

1. Notify the Engineer of concrete deliveries a minimum of 48 hours in advance of the scheduled placement. Include within this notification, the mix design and quantity of concrete, method and location of placement, frequency of trucks, ordered slump and time of initial delivery.
2. Furnish delivery batch ticket to the representative from the owner's testing laboratory or to the Engineer representative in the field with each batch delivered to the discharge locations in conformance with ASTM C94.

C. Test Measurements at Discharge:

1. The testing laboratory firm will take measurement of concrete slump, air content and temperature for each 50 cubic yards of each mix design but not less than once a day. The laboratory will conduct the slump, air content and temperature test measurements in conformance with ASTM C143, ASTM C231, and ASTM C1064, respectively.
2. The testing laboratory will submit test reports of field measurements specified above to the Contractor and to the Engineer.

D. Control Test Specimens:

1. The testing laboratory will cast a minimum of one set of three field control test specimens in conformance with ASTM C31 for each 150 cubic yards of each mix design of concrete but not less than once each day for each mix placed that day.
2. Laboratory personnel will record truck and load number from the delivery batch ticket, the concrete placement location of each specimen, the date, concrete strength, slump, air content, temperature and truck driver's name.
3. Furnish tightly constructed nonabsorbent test cylinder molds. Use molds of same type and manufacture for all test specimens. Leave molds on cylinders until received in testing laboratory.
4. Furnish boxes for initial curing of test cylinders in conformance with ASTM C31 from time of fabrication until they are transported to the testing laboratory.
5. The testing laboratory will compression test one of each set of three specimens at seven days. Immediately notify the Contractor and the Engineer if the seven-day strength is deficient. Test the two remaining cylinders at 56 days for concrete strength acceptance. The acceptance test result is the average of the strengths of the two specimens tested at 56 days. The laboratory firm will submit compression test results of the control test specimens to both the Contractor and the Engineer. Evaluation and acceptance of concrete shall conform to ACI 301 and ACI 318.

3.04 CURING AND PROTECTION:

- A. Protect CLSM from premature drying, hot or cold temperatures, and mechanical injury, beginning immediately after placement and maintain concrete with minimal moisture loss at relatively constant temperature.
- B. Comply with curing procedures set forth in ACI 301, applicable portions of ACI 308 and as specified herein.
- C. Perform hot weather concreting in conformance with ACI 305R and as specified herein when the ambient atmospheric temperature is 80 degrees F or above.
- D. Perform cold weather concreting in conformance with ACI 306R and as specified herein when the ambient atmospheric temperature is 40 degrees F or below.
- E. Protect Controlled Low Strength Material from traffic until sufficient strength has been achieved for further construction operations.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 41 13

PRECAST CONCRETE HOLLOW CORE PLANKS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide precast, prestressed, concrete hollow core planks including grouting of joints as indicated and in compliance with Contract Documents.
- B. Provide structural concrete topping in accordance with contract documents and Section 03 30 00.

1.02 REFERENCES:

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges
- B. American Concrete Institute (ACI):
 - 1. 301: Standard Specifications for Structural Concrete
 - 2. 304R: Guide for Measuring, Mixing, Transporting and Placing Concrete
 - 3. 305R: Hot Weather Concreting
 - 4. 306R: Cold Weather Concreting
 - 5. 308R: Guide to Curing Concrete
 - 6. 309R: Guide for Consolidation of Concrete
 - 7. 318: Building Code Requirements for Structural Concrete and Commentary
- C. American Institute of Steel Construction (AISC):
 - 1. AISC Manual of Steel Construction
- D. ASTM International (ASTM):
 - 1. A36: Standard Specification for Carbon Structural Steel
 - 2. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

3. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
4. A185: Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
5. A416: Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
6. A615: Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
7. A706: Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement
8. C33: Standard Specification for Concrete Aggregates
9. C150: Standard Specification for Portland Cement
10. D412: Standard Test Method for Rubber Properties in Tension

E. American Welding Society (AWS):

1. D1.1: Structural Welding Code, Steel
2. D1.4: Structural Welding Code, Reinforcing Steel

F. Prestressed Concrete Institute (PCI):

1. MNL-116: Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products

1.03 DESIGN CRITERIA:

- A. Design precast concrete hollow core planks in accordance with ACI 318 and PCI standards.
- B. Precast concrete hollow core plank shall be designed for the following:
 1. Dead Loads: Weight of unit, concrete topping, roof dead loads.
 2. Live Loads: As show on contract documents.
 3. Wind, Snow, Seismic, loads based on criteria shown on contract documents.
 4. Design planks for piping and equipment loads to be supported by the member. As a minimum the planks shall be designed for a uniform piping load of 15 pounds per square foot or a concentrated load of 2,000 pounds located at any point along the length of the member, whichever produces the most severe condition.

5. Handling and erection stresses.
6. Maximum deflection of span/240 for roof plank under live load.
7. Maximum deflection of span/360 for floor plank under live load.
8. Grouted keys shall be capable of transmitting horizontal shear force of 3000 pounds/foot.

1.04 QUALIFICATIONS:

- A. Fabricator: Company specializing in manufacturing the work of this section with five years' experience.
- B. Erector: Company specializing in erecting the work of this section with five years' experience.
- C. Welder: Qualified within previous 12 months in accordance with AWS.
- D. Design planks under direct supervision of Professional Structural Engineer experienced in design of this Work and licensed in the State that the units are to be installed in.

1.05 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 1. Completely detailed shop drawings for all precast, prestressed concrete planks. Indicate all dimensions, plank layout, architectural details, prestressing strands, reinforcing steel, inserts, connections, openings, edge conditions, bearing requirements, support conditions, lifting devices and openings intended to be field cut.
 2. Mark each member for identification. Show mark on erection plan and place legibly on unit at time of manufacture.
 3. Indicate design load and fire rating of units.
 4. Drawings shall bear the signature and seal of a Registered Professional Engineer employed by the precast manufacturer and licensed in the State of Utah.
 5. Calculations showing load intensities and combinations and deflections and cambers considered in design. Calculation shall bear the signature and seal of a Registered Professional Engineer employed by the precast manufacturer and licensed in the State of Utah.
 6. Concrete mix design.
 7. Test results of concrete mix used for production of the units.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Fabrication and quality control shall conform to MNL-116.
- C. The precast concrete manufacturing plant shall conform to the requirements of the Prestressed Concrete Institute Plant Certification Program.
- D. Furnish written welding procedure for all welds in conformance with the AWS.
- E. If a welder or welding operator has not been engaged in a specific welding process for a period of 12 months or more, that individual shall be deemed unqualified and shall not perform work on the project until the individual has been qualified again by testing in conformance with AWS.
- F. Maintain duplicate qualification and certification records at the job site readily available for examination.

1.07 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Store planks on clean blocking, off the ground and protected from rain and ground splatter. Cover planks with durable covers of canvas, heavy waterproof paper or plastic sheeting. Secure covers firmly and protect the planks from dust, dirt or other materials that may stain concrete.
- C. Separate stacked units with dunnage across the full width of each plank.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Furnish Portland cement conforming to ASTM C 150, Type I. Use one accepted brand from one mill throughout the contract term unless otherwise accepted by the Engineer. Use cement of uniform color.
- B. Use Concrete Aggregates that conform to ASTM C33. Size of coarse aggregate no larger than 3/4-inch but not exceeding space and cover requirements of prestressing and reinforcing steel.
- C. Water:
 - 1. Use water for concrete that is potable and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances, and conforms to the requirements for water in ASTM C94, and as specified herein.

2. The maximum water-soluble chloride ion in the water shall not exceed 0.060 percent by weight of cement.
- D. Concrete: Regular weight structural concrete with a minimum compressive strength of 5,000 psi at 28 days.
- E. Provide tensioning steel tendons with uncoated, seven wire, lowlax prestressing strand conforming to ASTM A416, Grade 270.
- F. Provide reinforcement steel with deformed bars conforming to ASTM A615, Grade 60.
- G. Provide weldable reinforcement with deformed bars conforming to ASTM A706, Grade 60, when welding is specified.
- H. Provide welded wire reinforcement conforming to ASTM A185.
- I. Steel Plates: ASTM A36, Hot-Dip Galvanized
- J. Metal inserts: Hot-dip galvanized ferrous metal conforming to ASTM A123 and ASTM A153. Do not embed aluminum in concrete.
- K. Bearing strip: 1/8-inch thick multi-monomer plastic.
- L. Grout: Mixture having not less than one part Portland cement to three parts fine sand and a minimum compressive strength of 3,000 psi at 28 days.

PART 3 - EXECUTION

3.01 FABRICATION:

- A. Fabricate concrete planks in accordance with M.L.-116 and Section 03 30 00.
- B. Extrude hollow-core planks in a factory with closely controlled mixing, placing and curing conditions. Cast solid planks in a factory. Do not cast units on site. Produce finished products free of honeycombs and voids with straight, true edges and surfaces.
- C. Machine finish top surface of plank except surfaces of planks to receive concrete topping shall be mechanically roughened by wire brush after casting.
- D. Provide a flat, smooth, steel form finish of uniform appearance on underside of plank.
- E. Cast all openings larger than 6-inch in greatest dimension or having an area of more than 36 square inches into planks at time of fabrication and properly reinforce. Smaller openings may be core-drilled in field when permitted by the Engineer who was responsible for the design of the precast planks.

- F. Incorporate welding clips, inserts, anchors, and sleeves indicated on drawings or required into planks at time of fabrication. Do not paint surfaces in contact with concrete or surfaces requiring field welding.
- G. Cure planks in accordance with MNL-116.

3.02 TOLERANCES:

- A. Erect members level and plumb within allowable tolerances. Conform to PCI MNL-116S.

3.03 INSTALLATION:

- A. Inspect bearing surfaces and ensure that the bearing surfaces are level and at the proper elevation.
- B. Place continuous bearing strips along bearing surfaces such that planks are uniformly supported across the full widths of the units.
- C. Lift and support members during transportation and erection at same points where members will be supported in completed structure.
- D. Remove protruding elements of lifting devices after erection of members.
- E. Protect members during lifting, transportation and handling operations against overstress, damage to surfaces and excessive forces. Do not install cracked or damaged planks. Only minor surface patching is permitted.
- F. Erect and install planks in accordance with manufacturer's written instructions using experienced workmen. Accurately place and adjust planks to correct alignment and elevation before securing in place. Locate connections and welds in accordance with accepted shop drawings. Inspect welded connections before covering with concrete topping or roofing materials.
- G. Alignment: Level and match underside of adjacent planks by, jacking, shoring or loading to produce a uniform ceiling plane.
- H. Grout joints between planks using the specified grout. Make bottom of joints smooth in areas where underside of plank is exposed. Trowel top of joints smooth. Remove grout that seeps from joints between planks before it hardens.
- I. Field cutting or coring is not permitted without the written permission of the Engineer who was responsible for the design of the precast planks. Powder driven fasteners into planks are not permitted.
- J. When permitted by the Engineer who was responsible for the design of the precast planks, cutting or coring of plank may be performed after grout in shear keys have attained their design strength.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 60 00

GROUT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Furnish all labor, materials, equipment, and incidentals required, and install grout complete as shown on the Drawings and as indicated and in compliance with Contract Documents.

1.02 SUMMARY:

A. Section Includes:

1. Material for grouting reinforcing bars, anchor bolts into existing or newly placed concrete.
2. Material for grouting under bearing plates for columns or beams.
3. Materials for grouting under equipment.
4. Materials for miscellaneous grouting including but not limited to railing posts, equipment guides, bollards, precast concrete joints and supports etc.

1.03 REFERENCE STANDARDS:

A. American Association of State Highway and Transportation Officials (AASHTO):

1. M182: Burlap Cloth made from Jute or Kenaf

B. American Petroleum Institute (API):

1. RP 686: Recommended Practice for Machinery Installation and Installation Design

C. ASTM International (ASTM):

1. C33: Standard Specification for Concrete Aggregates
2. C150: Standard Specification for Portland Cement
3. C531: Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts, and Monolithic Surfacing
4. C827: Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixes

5. C1107: Standard Specification for Packaged Dry, Hydraulic, Cement Grout (Non-shrink)

6. D695: Standard Test Method for Compressive Properties of Rigid Plastics

D. U.S. Army Corps of Engineers Standard (CRD):

1. C621: Corps of Engineers Specification for Non-shrink Grout

1.04 DESIGN REQUIREMENTS:

A. Design grout and related anchorage systems in accordance with the design loads specified on the contract drawings or as required by the equipment manufacturer.

B. The design and selection of the grout and grouting system shall be based on the duration and magnitude of the load and the frequency of application. The use of a grout for a specific application shall be verified by the manufacturer of the grout.

1.05 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Product Data:

1. Commercially manufactured non-shrink, non-metallic cementitious grout:

a. Include catalog cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to referenced ASTM standards, and Material Safety Data Sheet (MSDS).

2. Commercially manufactured non-shrink epoxy grout:

a. Include catalog cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to referenced ASTM Standards and Material Safety Data Sheet (MSDS).

3. Cement Grout:

a. Include the type and brand of the cement, the gradation of the fine aggregate, product data on any proposed admixtures, and the proposed mix of the grout.

4. Concrete Grout:

a. Include data for concrete as delineated in Section 03 30 00. This includes the mix design, constituent quantities per cubic yard, and the water/cement ratio.

5. Bonding Agent:

- a. Include catalog cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to referenced ASTM standards, and Material Safety Data Sheet (MSDS).

C. Laboratory Test Reports.

1. Submit laboratory test data as required under Section 03 30 00 for concrete to be used as concrete grout.

D. Mill test reports for each shipment of cement, regardless of quantity, prior to incorporation into the work.

E. Manufacturer's specifications and instructions for all admixtures, curing materials, adjustable inserts and non-shrink non-metallic grout. Manufacturer's certification of compatibility of all admixtures.

1.06 QUALITY ASSURANCE:

A. Qualifications

1. Grout manufacturer to have a minimum of 5 years' experience in the production and use of the type of grout proposed for the Work.

B. Field Testing

1. Field testing and inspection services required will be provided by the Owner. Provide assistance in the sampling of materials and provide any ladders, platforms, etc. for access to the Work. Comply with the applicable ASTM Standards for testing.
2. The field testing of concrete grout will be as specified for concrete in Section 03 30 00.
3. Take compression test specimens from the first placement of each type of grout to ensure compliance with these Specifications.
 - a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at one, seven and 28 days.
 - b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C579, Method B. A set of three specimens will be made for testing at seven days.

1.07 RESPONSIBILITIES:

- A. Assist the Owner in obtaining specimens for testing and furnish all materials necessary for fabricating the test specimens.
- B. The cost of laboratory tests on grout will be paid by the Owner except where test results show the grout to be defective. In such case, the Contractor shall pay for the tests, removal and replacement of defective work, and re-testing all at no cost to the Owner.

1.08 WARRANTY:

- A. Warrant the materials and products specified in this Section against defective materials and workmanship with the manufacturer's standard warranty, but for no less than one year from the date of substantial completion.
- B. Warrant the work against defects for one year from the date of substantial completion.

1.09 DELIVERY, STORAGE, AND HANDLING:

- A. Comply with the requirements in Section 01 66 10.
- B. Deliver materials to the jobsite in original, unopened packages, clearly labeled with the manufacturer's name, product identification, batch numbers, and printed instructions.
- C. Store materials in accordance with the manufacturer's recommendations. Total storage time from date of manufacture to date of installation shall be limited to six months or the manufacturer's recommended storage time, whichever is less.
- D. Reject material that becomes damp, lumpy or otherwise unacceptable and immediately remove from the site and replace with acceptable material at no cost to the Owner.
- E. Deliver non-shrink cement based grouts as pre-blended, prepackaged mixes requiring only the addition of water.
- F. Deliver non-shrink epoxy grouts as premeasured, prepackaged, three component systems requiring only blending as directed by the manufacturer.

1.10 SERVICES OF MANUFACTURER'S REPRESENTATIVE:

- A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall instruct the Contractor's personnel in the mixing, proper use and application of the non-shrink grout and epoxy grout.
- B. The manufacturer's representative shall provide written certification that materials have been mixed and applied properly and surfaces to receive these products have been prepared properly, all in conformance with manufacturer's requirements.
- C. The on-site time required for the manufacturer's representative to achieve a successful installation shall be at the expense of the Contractor.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Provide materials produced by one manufacturer or supplier in order to provide standardization of appearance.

2.02 APPLICATION:

- A. Unless indicated otherwise, provide grouts as listed below:

Table 03 60 00-1	
Type of Grout	Application
Cement Grout	Surface repairs
Non-Shrink – Class I	Storage tanks and other non-motorized equipment.
	Filling block-out spaces for embedded items such as railing posts, gate guide frames, etc. (Where placement time is less than 20 minutes.)
	Repair of holes and defects in concrete members that are not water bearing and not in contact with soil or other fill material.
Non-Shrink – Class II	Column base plates.
	Filling block-out spaces for embedded items such as railing posts, gate guide frames, etc. (Where placement time exceeds 20 minutes.)
	Under precast concrete elements.
Non-Shrink Epoxy	Machinery subject to severe shock loads and high vibration.
Concrete Grout	Toppings and concrete/grout fill, bottom of liquid containing concrete walls.

2.03 MATERIALS:

- A. Non-shrink Class I Grout:

1. Non-shrink Class I Grout shall have a minimum 28-day compressive strength of 5000 psi, when mixed at a fluid consistency.
2. Non-shrink Class I grout shall meet the requirements of ASTM C1107, Grade B or C, when mixed to fluid, flowable and plastic consistencies.
3. Products:
 - a. Sika Corporation; SikaGrout 212
 - b. Master Builders, Inc.; Set Grout

- c. The Euclid Chemical Company; Euco NS

B. Non-shrink Class II Grout:

1. Non-shrink grout shall be a high precision, fluid, extended working time grout. The minimum 28-day compressive strength shall be 7,500 psi, when mixed at a fluid consistency.
2. Grout shall have an extended working time of 30 minutes minimum when mixed to a fluid consistency as defined in ASTM C827 at temperature extremes of 45 to 90 degrees F in accordance with ASTM C1107.
3. Non-shrink grouts shall meet the requirements of ASTM C1107; Grade B or C when tested using the amount of water needed to achieve fluid consistency per ASTM C939.
4. The grout when tested shall not bleed or segregate at maximum allowed water.
5. Products:
 - a. Master Builders, Inc.; Masterflow 928
 - b. The Euclid Chemical Company; Hi-Flow Grout
 - c. Sika Corporation; SikaGrout 212

C. Cement Grout:

1. Cement grouts shall be a mixture of one part portland cement conforming to ASTM C150 types I, II, or III and one to two parts sand conforming to ASTM C33 with sufficient water to place the grout. The water content shall be sufficient to impart workability to the grout, but not to the degree that it will allow the grout to flow.
2. Cement grout materials shall be as indicated in Section 03 30 00.

D. Concrete Grout:

1. Concrete grout shall conform to the requirements of Section 03 30 00 except as specified herein. Proportion with cement, coarse and fine aggregates, water, water reducer, and air entraining agent to produce a mix having an average strength of 5,000 psi at 28 days. Coarse aggregate size shall be 3/8-inch maximum. Keep the W/C ratio as low as practical while still retaining sufficient workability.

E. Non-shrink Epoxy-Based Grout:

1. Provide a pre-proportioned, three component, 100 percent solids system consisting of epoxy resin, hardener, and blended aggregate. It shall have a compressive strength of 14,000 psi in seven days when tested in conformity with ASTM D695 and have

a maximum thermal expansion of 30×10^{-6} when tested in conformity with ASTM C531.

2. Products:

- a. Master Builders, Inc.; Ceilcote 648 CP
- b. U.S. Grout Corporation; Five Star Epoxy Grout
- c. Sika Corporation; Sikadur 42 Grout-Pak
- d. The Euclid Chemical Company; High Strength Epoxy Grout

F. Dry Pack Grout:

- 1. Make dry pack (to be packed or tamped in place) at no slump consistency.
- 2. When mixing the batch, add only enough water to the dry materials to produce a rather stiff mixture. Additions of water may be made in small increments until the desired consistency is obtained.

G. Non-epoxy Bonding Compound:

- 1. Provide non-epoxy bonding compound that is re-wetable for up to two weeks.
- 2. Products:
 - a. Larsen Products Corporation; Weldcrete
 - b. Sta-Dry Manufacturing Corporation; Link
 - c. The Euclid Chemical Company; Euco Weld

2.04 CURING MATERIALS:

- A. Curing materials for cement grout shall be as specified in Specification 03 30 00 and as recommended by the manufacturer for prepackaged grouts.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Grout shall not be placed until base concrete has attained its design strength, unless authorized otherwise by the Engineer.
- B. Prepare surfaces for curing, and protection of cement grout in accordance with Section 03 30 00.

- C. Shade the work sites from sunlight for at least 24 hours before and 48 hours after grouting.
- D. Contact the grout manufacturer's representative for assistance on hot and cold weather grouting techniques and precautions if applicable.

3.02 PREPARATION:

- A. Clean concrete surfaces to receive grout free of ice, frost, dirt, grease, oil, curing compounds, laitance and paints, and free of all loose or unsound material or foreign matter that may affect the bond or performance of the grout.
- B. Roughen concrete surfaces by chipping, sandblasting, or other mechanical means to ensure bond of the grout to the concrete. Remove loose or broken concrete. Irregular voids or projecting coarse aggregate need not be removed if they are sound, free of laitance and firmly embedded into the parent concrete.
- C. Remove all loose rust, oil or other deleterious substances from metal embedments prior to the installation of the grout.
- D. Wash concrete surfaces clean and keep them moist for at least 24 hours prior to the placement of cementitious or cement grout. Saturate by covering the concrete with a plastic sheet or using either a soaker hose, flooding the surface or other method acceptable to the Engineer. Remove visible water from the surface upon completion of the 24-hour period prior to grouting. Use an accepted adhesive bonding agent in lieu of surface saturation when accepted by the Engineer for each specific location of grout installation.
- E. Epoxy based grouts do not require the saturation of the concrete substrate. Surfaces in contact with epoxy grout shall be completely dry before grouting.
- F. Construct grout forms or other leak proof containment. Forms shall be lined or coated with release agents recommended by the grout manufacturer.
- G. Support equipment during alignment and installation of grout by shims, wedges, blocks, or other accepted means. Prevent the shims, wedges, and blocking devices from bonding to the grout by appropriate bond breaking coatings and remove them after grouting unless otherwise accepted by the Engineer.
- H. The embedment depth for epoxy grouted anchor bolts and threaded rod anchors shall be at least 15 bolt or rod diameters, unless otherwise indicated on the drawings. Holes shall be prepared for grouting as recommended by the grout manufacturer.

3.03 INSTALLATION:

- A. Anchor bolts and threaded rod anchors:
 - 1. Anchor bolts and threaded rod anchors shall be clean, dry and free of grease and other foreign matter when installed. The bolts, rods and bars shall be set and positioned and the epoxy grout shall be placed and finished in accordance with the

recommendations of the grout manufacturer. Care shall be taken to ensure that all spaces and cavities are filled with epoxy grout, without voids. During assembly of all threaded stainless steel components, anti-seize thread lubricant shall be liberally applied to the threaded portion not embedded in concrete grouting machinery foundations

2. Block out the original concrete or finish off a sufficient distance below the bottom of the machinery base to provide for the thickness of grout shown on the Contract Drawings. After the machinery has been set in position and placed at the proper elevation by steel wedges, the space between the bottom of the machinery base and the original placement of concrete shall be filled with a pourable non-shrink grout. Grout and grouting procedure shall be in accordance with API 686.

B. Cement Grouts and Non-shrink Cementitious Grouts:

1. Mix in accordance with manufacturer's recommendations. Do not add cement, sand, pea gravel, or admixtures without prior approval by the grout manufacturer and the Engineer.
2. Avoid mixing by hand. Pre-wet the mixer and empty excess water. Add premeasured amount of water for mixing, followed by the grout. Begin with the minimum amount of water recommended by the manufacturer and then add the additional water required to obtain workability. However, do not exceed the manufacturer's maximum recommended water content.
3. Place grout into the designated areas in a manner that will avoid segregation or entrapment of air. Do not vibrate grout to release air or to consolidate the material. Placement should proceed in a manner that will ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary. Place grout rapidly and continuously to avoid cold joints. Do not place cement grouts in layers. Do not add additional water to the mix (re-temper) after initial stiffening.
4. Just before the grout reaches its final set, cut back the grout to the substrate at a 45-degree angle from the lower edge of bearing plate unless otherwise accepted by the Engineer.
5. Begin curing immediately after form removal, cutback, and finishing. Keep grout moist and within its recommended placement temperature range for at least 24 hours after placement or longer if recommended by the manufacturer.

C. Non-Shrink Epoxy Grouts:

1. Apply bonding agent, if required, in accordance with the requirements of the grout manufacturer. Mix in accordance with the procedures recommended by the manufacturer. Do not vary the ratio of components or add solvent to change the consistency of the grout mix. Do not over mix. Mix full batches only to maintain

proper proportions of resin, hardener, and aggregate. Partial mixes will be rejected and will require the suspect grout to be removed and be replaced.

2. Monitor ambient weather conditions and contact the grout manufacturer for special placement procedures to be used for temperatures below 60 degrees F or above 90 degrees F.
3. Place grout into the designated areas in a manner that will avoid trapping air. Placement methods shall ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary.
4. The extension of grout horizontally beyond base plate shall be less than or equal to the grout thickness.
5. Epoxy grouts are self-curing and do not require the application of water. Maintain the formed grout within its recommended placement temperature range for at least 24 hours after placing, or longer if recommended by the manufacturer.

D. Concrete Grout:

1. Provide the underlying concrete surface with a broomed finish. Protect and keep the surface clean until placement of concrete grout.
2. Remove the debris and clean the surface of all dirt and other foreign materials.
3. Saturate the concrete surface for at least 24 hours prior to placement of the concrete grout. Remove excess water just prior to placement of the concrete grout. Place a cement slurry immediately ahead of the concrete grout so that the slurry is moist when the grout is placed. Work the slurry over the surface with a broom until it is coated with approximately 1/16- to 1/8-inch thick cement paste.

E. Dry Pack:

1. Dry pack consistency shall be such that the grout is plastic and moldable but will not flow.
2. The use of pneumatic pressure for dry-packed grouting requires acceptance of the Engineer.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 64 23

CRACK REPAIR EPOXY INJECTION GROUTING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide crack repair epoxy injection grout as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. T237: Standard Method of Test for Testing Epoxy Resin Adhesive.
- B. American National Standards Institute (ANSI).
- C. ASTM International (ASTM):
 - 1. C882: Standard Specification for Test Method for Bond Strength of Epoxy-Resin System Used with Concrete by Slant Shear.
 - 2. D570: Standard Test Method for Water Absorption of Plastics.
 - 3. D638: Standard Test Method for Tensile Properties of Plastics.
 - 4. D648: Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
 - 5. D695: Standard Test Method for Compressive Properties of Rigid Plastics.
 - 6. D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 DEFINITIONS:

- A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.
- B. Crack Injection: method of sealing or repairing cracks by injecting a polymer.
- C. Large Cracks: wider than 0.008 inch, inject all.
- D. Moderate Cracks: width greater than or equal to 0.005 inch and less than 0.008 inch, inject leaking cracks.

- E. Small Cracks: width equal to 0.005 inch or less. Repair leaking cracks per method approved by Engineer if unable to inject.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Physical and chemical properties for epoxy adhesives.
 - 2. Technical data for metering, mixing, and injection equipment.
 - 3. Drawings and photos of proposed injection locations. Do not proceed with injection until review by Engineer is complete.
 - 4. Manufacturer's recommended surface preparation procedures and application instructions for epoxy adhesives.
 - 5. Installation instructions for repairing core holes with epoxy grout.
 - 6. Manufacturer's Certificate of Compliance: certified test results for each batch of epoxy adhesive.
 - 7. Statements of Qualification for Epoxy Adhesive:
 - a. Manufacturer's site representative.
 - b. Injection applicator.
 - c. Injection pump operating technician.
 - 8. Epoxy adhesive two component ratio and injection pressure test records for concrete crack repair work.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Qualifications for Epoxy Injection Staff:
 - 1. Manufacturer's site representative:
 - a. Capable of instructing successful methods for restoring concrete structures utilizing epoxy injection process.

- b. Understands and is capable of explaining technical aspects of correct material selection and use.
 - c. Experienced in the operation, maintenance, and troubleshooting of application equipment.
- 2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
 - a. Licensed and certified by epoxy manufacturer.
 - b. Minimum 3 years' experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection including 2,000 linear feet of wet crack injection to stop water leakage.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Packing and Shipping: package adhesive material in new sealed containers and label with following information:
 - 1. Manufacturer's name.
 - 2. Product name and lot number.
 - 3. ANSI Hazard Classification.
 - 4. ANSI recommended precautions for handling.
 - 5. Mix ratio by volume.
- C. Storage and Protection: Store adhesive containers at ambient temperatures below 110 degrees F and above 45 degrees F.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Materials, equipment, and accessories specified in this Section shall be products of:
 - 1. BASF Building Systems, Shakopee, MN; SCB Concrasive Series
 - 2. Sika Corporation, Lyndhurst, NJ; Sikadur Series
 - 3. The Euclid Chemical Company, Cleveland, OH; Euco Series

2.02 EPOXY ADHESIVE:

- A. Two-component A and B structural epoxy adhesive for injection into cracks or other voids in concrete structures for bonding or grouting.
- B. Adhesive Properties:

	Test Method	
7-day, Tensile Strength, psi	ASTM D638	5,000 min.
Tensile Elongation @ Break, percent	ASTM D638	1.0% min.
Compressive Yield Strength, 7 days @ 73 degrees F, psi	ASTM D695 ^a	8,000 min.
Compressive Modulus, psi	ASTM D695 ^a	1.5x10 ⁵ min.
Heat Deflection Temperature, °F	ASTM D648 ^a	120 min. ^a
Water absorption @ 24 hours, maximum %	ASTM D570	1.0
Bond Strength @ 2 days psi	ASTM C882	1,000 min.
Bond Strength @ 14 days psi	ASTM C882	1,500 min.
Slant Shear Strength: (5,000 psi Compressive Strength Conc.) (Where test results are available psi.)	AASHTO T237 ^b	
Cured 3 days @ 40 degrees F—Wet Concrete		3,500 min.
Cured 1 day @ 77 degrees F—Dry Concrete		5,000 min.
Cured 3 days @ 77 degrees plus or minus 3 degrees F		5,000 min.
^a Cure test specimens so that peak exothermic temperature of adhesive does not exceed 100 degrees F.		
^b See referenced specifications for preparation method of test specimens.		

2.03 SURFACE SEAL:

- A. Sufficient strength and adhesion for holding injection fittings firmly in place, and to resist pressures preventing leakage during injection.
- B. Capable of removal after injection adhesive has cured.

2.04 SOURCE QUALITY CONTROL:

- A. Test Requirements: perform tests for each batch of adhesive.
- B. Pot Life Test:
 - 1. Condition Components A and B to required temperature.

2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid ounce paper cup.
 3. Start stopwatch immediately and mix components for 60 seconds using wooden tongue depressor, take care to scrape sides and bottom of cup periodically.
 4. Probe mixture once with tongue depressor every 30 seconds, starting 2 minutes prior to minimum specified pot life.
 5. Pot Life Definition: time at which a soft stringy mass forms in center of cup.
- C. Fabrication of Slant Shear Specimens for Testing Bond of Injectable Adhesives to Wet Concrete at 40 degrees F:
1. Scope: Test method for preparation of diagonal concrete mortar blocks used in determining slant shear strength of low viscosity injectable adhesives in accordance with AASHTO T237 when concrete is wet.
 2. Materials:
 - a. Diagonal concrete mortar blocks prepared in accordance with AASHTO Test Method T237 and cured to produce a mortar with compressive strength of 5,000 psi or greater.
 - b. Paraffin wax.
 - c. Masking Tape: 3/4 inch wide.
 - d. Suitable 20-mil-thick shim stock.
 3. Preparation:
 - a. Place a 20-mil shim between diagonal faces of two blocks and align so ends and sides are square.
 - b. Bind block with masking tape covering gap between blocks.
 - c. Leave a gap between blocks on one face uncovered for removal of shim and application of adhesive.
 - d. Paint melted paraffin wax over masking tape.
 - e. Shallow dam may be built up around opening using paraffin wax or modeling clay to help retain adhesive.
 - f. Apply suitable capping compound to each end of specimen producing smooth surfaces perpendicular to longitudinal axis of block.
 - g. Remove shim stock from gap opening.

- h. Soak specimen in water at 40 degrees F, plus or minus 3 degrees F for at least 24 hours.
- i. After soaking, remove specimen, shake free water from surface and gap opening.
- j. Prepare liquid adhesive.
- k. Within 5 minutes after removing specimen from water, start flowing adhesive into crack without entrap air bubbles.
- l. Place specimen in 40 degrees F, plus or minus 3 degrees F ambient for curing within 15 minutes after removing specimen from water for bonding. Do not expose specimen to temperatures beyond 77 degrees F during the 15-minute period.
- m. Cure specimen for 72 hours, plus or minus 4 hours at 40 degrees F, plus or minus 3 degrees F.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Structurally repair cracks in structures as specified in Section 03 30 00.
- B. Cracks: repair by injection of epoxy adhesive.

3.02 PREPARATION:

- A. Free cracks from loose matter, dirt, laitance, oil, grease, salt, and other contaminants.
- B. Clean cracks in accordance with epoxy adhesive manufacturer's instructions.
- C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.
- D. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting epoxy.

3.03 APPLICATION:

- A. Sealing: apply surface seal in accordance with manufacturer's instructions to designated crack face prior to injection; seal surface of crack to prevent escape of injection epoxy.
- B. Entry Ports:
 - 1. Establish openings for epoxy entry in surface seal along crack.

2. Determine space between entry ports equal to thickness of concrete member to allow epoxy to penetrate to the full thickness of the wall.
3. Provide a means to prevent concrete dusts and fines from contaminating the crack or ports when drilling.
4. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
 - a. Cracks extend entirely through wall.
 - b. Backfill of walls on one side.
 - c. Difficult to excavate behind wall to seal both crack surfaces.
5. Core drill to verify epoxy depth where only one side of wall is exposed.

C. Epoxy Injection:

1. Store epoxy at minimum of 70 degrees F.
2. Start injection into each crack at lowest elevation entry port.
3. Continue injection at first port until adhesive begins to flow out of port at next highest elevation.
4. Plug first port and start injection at second port until adhesive flows from next port.
5. Inject entire crack with same sequence.

D. Finishing:

1. Cure epoxy adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy material from cracks.
2. Remove surface seal from cured injection adhesive.
3. Finish crack face flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports are not acceptable.
5. Remove surface seal material and injection adhesive runs and spills from concrete surfaces.

3.04 EQUIPMENT:

- A. Portable, positive displacement-type pumps with in-line metering to meter and mix two adhesive components, and inject mixture into crack.

B. Pumps:

1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
3. Capable of immediate compensation for changes in resins.
4. Do not use batch mix pumps.

C. Discharge Pressure: automatic pressure controls capable of discharging mixed adhesive at pressures up to 200 psi, plus or minus 5 percent, and able to maintain pressure.

D. Automatic Shutoff Control: provide sensors on both Component A and B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

E. Proportioning Ratio Tolerance: maintain epoxy adhesive manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 psi.

F. Ratio/Pressure Check Device:

1. Two independent, valved nozzles, capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge, capable of sensing pressure behind each valve.

3.05 FIELD QUALITY CONTROL:

A. Epoxy Adhesive Two Component Ratio Tests:

1. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 psi for both adhesive components.
3. Simultaneously discharge both adhesive components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.

6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1 hour.
7. Document and maintain complete accurate records of, ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.
2. Pressure Check Device:
 - a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
 - b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
 - a. Beginning and end of each injection work day.
 - b. When injection work as stop for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Crack Injection Tests:

1. Initial Cores:
 - a. 4-inch-diameter for full crack depth taken from Engineer's selected locations.
 - b. Take three cores in first 100 linear feet of crack repaired and one core sample for each 500 linear feet thereafter.
2. Provide suitable containers for storage, curing, and transportation of test specimens.
3. Methods of Testing Cores:
 - a. Penetration: Visual examination.
 - b. Bond Strength/Compression Test: concrete failure prior to adhesive failure.

4. Test Requirements:

- a. Penetration: minimum of 90 percent of crack shall be full of epoxy adhesive.
- b. Bond Strength/Compression Test: concrete failure before adhesive failure, or 6,500 psi with no failure of either concrete or adhesive.

5. Evaluation and Acceptance of Tests:

- a. If initial cores pass tests as specified, epoxy adhesive injection at area represented by cores will be accepted.
- b. If initial cores fail either by lack of penetration or bond strength, crack repair shall not proceed further until areas represented by cores are re-injected or repaired and retested for acceptance.
- c. Obtain verifying core samples, number and location as selected by Engineer, after rework of areas represented by failed initial cores is complete.

6. Core Hole Repair:

- a. Correct as result of testing on notification from Engineer.
- b. Refill initial and verifying core holes with an epoxy grout tamped and rodded in-place to form a dense fill.
- c. Finish surface to blend with adjacent concrete.

3.06 TESTS AND INSPECTIONS:

- A. Special inspection, testing, and professional observation shall be provided by the Contractor as indicated in the Statement of Special Inspection in the Drawings and in Section 01 45 33.
- B. Special Inspector shall verify that manufacturer and installer's procedures and instructions for surface preparation and installation are followed.

3.07 ALTERNATIVE CRACK REPAIRS:

- A. Where specifically approved in writing by the Engineer, alternative crack repair products and procedures may be used, as Specified in Section 03 01 30.
- B. Each individual location where alternative crack repair products or procedures are used, shall be approved in writing by the Engineer, prior to beginning work or installing the alternative products.

3.08 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 04 22 00
CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Concrete masonry units.
2. Decorative concrete masonry units.
3. Cast stone trim.
4. Mortar and grout.
5. Steel reinforcing bars.
6. Masonry-joint reinforcement.
7. Embedded flashing.
8. Miscellaneous masonry accessories.
9. Masonry-cell insulation.

B. Related Requirements:

1. Section 07 19 00 for water repellents applied to unit masonry assemblies.

1.02 DEFINITIONS

- A. CMU(s): Concrete masonry unit(s).
- B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.03 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. For decorative CMU and cast stone trim, include full range of manufacturer's colors and textures.

B. Shop Drawings: For the following:

1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
2. Show fabrication and installation details for cast stone trim units. Include dimensions, details of reinforcement and anchorages if any, and indication of finished faces.
3. Reinforcing Steel: Detail bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315. Show elevations of reinforced walls.
4. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.

C. Samples for Initial Selection:

1. Decorative CMUs, in the form of small-scale units.
2. Cast stone trim.
3. Colored mortar.

D. Samples for Verification: For each type and color of the following:

1. Decorative CMUs.
2. Cast stone trim.
3. Colored mortar. Make Samples using same sand and mortar ingredients to be used on Project.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Material Certificates: For each type and size of the following:

1. Masonry units.
 - a. Include material test reports substantiating compliance with requirements.
 - b. For masonry units used in structural masonry, include data and calculations establishing average net-area compressive strength of units.
2. Cast stone trim.
3. Integral water repellent used in CMUs.
4. Cementitious materials. Include name of manufacturer, brand name, and type.

5. Mortar admixtures.
 6. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
 7. Grout mixes. Include description of type and proportions of ingredients.
 8. Reinforcing bars.
 9. Joint reinforcement.
 10. Anchors, ties, and metal accessories.
- C. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.
1. Include test reports for mortar mixes required to comply with property specification. Test in accordance with ASTM C109/C109M for compressive strength, ASTM C1506 for water retention, and ASTM C91/C91M for air content.
 2. Include test reports, in accordance with ASTM C1019, for grout mixes required to comply with compressive strength requirement.
- D. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined in accordance with TMS 602/ACI 530.1/ASCE 6.
- E. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.
- 1.06 QUALITY ASSURANCE
- A. Testing Agency Qualifications: Qualified in accordance with ASTM C1093 for testing indicated.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
1. Refer to Drawings and Section 01 43 39.
 2. Protect accepted mockups from the elements with weather-resistant membrane.
 3. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
 - a. Approval of mockups is also for other material and construction qualities specifically approved by Engineer in writing.

- b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.
- E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.08 FIELD CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
 - 1. Extend cover a minimum of 24 inches (600 mm) down both sides of walls, and hold cover securely in place.
- B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.
- C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
 - 1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 - 2. Protect sills, ledges, and projections from mortar droppings.
 - 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.

4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations for Masonry Units: Obtain exposed, exterior masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required. This includes both the exterior split-face and smooth CMU.
- B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

2.02 PERFORMANCE REQUIREMENTS

- A. Provide structural unit masonry that develops indicated net-area compressive strengths at 28 days.
 1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) in accordance with TMS 602/ACI 530.1/ASCE 6.
 2. Determine net-area compressive strength of masonry by testing masonry prisms in accordance with ASTM C1314.

2.03 UNIT MASONRY, GENERAL

- A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6 except as modified by requirements in the Contract Documents.

- B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work.
- C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.
 - 1. Where fire-resistance-rated construction is indicated, units are listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction.

2.04 CONCRETE MASONRY UNITS

- A. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
 - 1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
 - 2. Provide bullnose units for outside corners unless otherwise indicated.
- B. Integral Water Repellent: Provide units made with integral water repellent for exterior exposed units and where indicated.
 - 1. Integral Water Repellent: Liquid polymeric, integral water-repellent admixture that does not reduce flexural bond strength. Units made with integral water repellent, when tested in accordance with ASTM E514/E514M as a wall assembly made with mortar containing integral water-repellent manufacturer's mortar additive, with test period extended to 24 hours, show no visible water or leaks on the back of test specimen.
- C. Masonry Cell Insulation: Where indicated, units contain rigid, specially shaped, molded-polystyrene insulation units complying with ASTM C578, Type I, designed for installing in cores of masonry units.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Concrete Block Insulating Systems; KORFIL or a comparable product by one of the following:
 - a. Shelter Enterprises Inc.
 - 2. Physical Properties:
 - a. Typical Density: Minimum 1.05 lbs/cu. ft.
 - b. Thermal Resistance (R-value/inch): 5.00
- D. CMUs: ASTM C90.
 - 1. Density Classification: Normal weight.

2. Size (Width): Manufactured to dimensions 3/8 inch (10 mm) less-than-nominal dimensions.
 3. Application: Interior partitions.
- E. Decorative CMUs: ASTM C90.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Sunroc Masonry or comparable product by one of the following:
 - a. AMCOR Masonry
 - b. Echelon Masonry
 2. Density Classification: Normal weight.
 3. Size (Width): Manufactured to dimensions specified in "CMUs" Paragraph.
 4. Application: Exterior walls including split-face and smooth CMU.
 5. Colors and Textures: Refer to Drawings.

2.05 MASONRY LINTELS

- A. General: Provide one of the following:
1. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

2.06 CAST STONE TRIM UNITS

- A. Cast Stone Units: Comply with ASTM C1364.
1. Trim units including wall caps where indicated on Drawings.
- B. Fabricate units with sharp arris with indicated texture on all exposed surfaces unless otherwise indicated.
1. Slope exposed horizontal surfaces 1:12 to drain unless otherwise indicated.
 2. Provide drips on projecting elements unless otherwise indicated.
- C. Fabrication Tolerances:
1. Variation in Cross Section: Do not vary from indicated dimensions by more than 1/8 inch (3 mm).

2. Variation in Length: Do not vary from indicated dimensions by more than 1/360 of the length of unit or 1/8 inch (3 mm), whichever is greater, but in no case by more than 1/4 inch (6 mm).
3. Warp, Bow, and Twist: Not to exceed 1/360 of the length of unit or 1/8 inch (3 mm), whichever is greater.
4. Location of Grooves, False Joints, Holes, Anchorages, and Similar Features: Do not vary from indicated position by more than 1/8 inch (3 mm) on formed surfaces of units and 3/8 inch (10 mm) on unformed surfaces.

D. Cure Units as Follows:

1. Cure units in enclosed, moist curing room at 95 percent relative humidity and temperature of 100 deg F (38 deg C) for 12 hours or 70 deg F (21 deg C) for 16 hours.
2. Keep units damp and continue curing to comply with one of the following:
 - a. No fewer than five days at mean daily temperature of 70 deg F (21 deg C) or above.
 - b. No fewer than seven days at mean daily temperature of 50 deg F (10 deg C) or above.

E. Acid etch units after curing to remove cement film from surfaces to be exposed to view.

F. Colors and Textures: As selected by Engineer from manufacturer's full range.

2.07 MORTAR AND GROUT MATERIALS

A. Hydraulic Blended Cement: ASTM C595, Type IL . Provide natural color or white cement as required to produce mortar color indicated.

1. Alkali content is not more than 0.1 percent when tested in accordance with ASTM C114.

B. Hydrated Lime: ASTM C207, Type S.

C. Cement-Lime Mix: Packaged blend of cement and hydrated lime containing no other ingredients.

D. Masonry Cement: ASTM C91/C91M.

E. Mortar Cement: ASTM C1329/C1329M.

F. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C979/C979M. Use only pigments with a record of satisfactory performance in masonry mortar.

- G. Colored Cement Products: Packaged blend made from cement and hydrated lime and mortar pigments, all complying with specified requirements, and containing no other ingredients.
 - 1. Formulate blend as required to produce color indicated or, if not indicated, as selected from manufacturer's standard colors.
 - 2. Pigments does not exceed 10 percent of cement by weight.
 - 3. Mortar color: As selected by Engineer from manufacturer's full range
- H. Aggregate for Mortar: ASTM C144.
 - 1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
 - 2. For joints less than 1/4 inch (6 mm) thick, use aggregate graded with 100 percent passing the No. 16 (1.18-mm) sieve.
 - 3. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.
- I. Aggregate for Grout: ASTM C404.
- J. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs containing integral water repellent from same manufacturer.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Euclid Chemical Company (The); an RPM company.
 - b. GCP Applied Technologies Inc.
 - c. Master Builders Solutions.

K. Water: Potable.

2.08 REINFORCEMENT

- A. Uncoated Steel Reinforcing Bars: ASTM A615/A615M or ASTM A996/A996M, Grade 60.
- B. Vertical Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.

2.09 TIES AND ANCHORS

- A. General: Ties and anchors extend at least 1-1/2 inches (38 mm) into masonry but with at least a 5/8-inch (16-mm) cover on outside face.
- B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
 - 1. Mill-Galvanized, Carbon-Steel Wire: ASTM A82/A82M, with ASTM A641/A641M, Class 1 coating.
 - 2. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A82/A82M, with ASTM A153/A153M, Class B-2 coating.
 - 3. Stainless Steel Wire: ASTM A580/A580M, Type 304.
 - 4. Galvanized-Steel Sheet: ASTM A653/A653M, Commercial Steel, G60 zinc coating.
 - 5. Steel Sheet, Galvanized after Fabrication: ASTM A1008/A1008M, Commercial Steel, with ASTM A153/A153M, Class B coating.
 - 6. Stainless Steel Sheet: ASTM A240/A240M or ASTM A666, Type 304.
 - 7. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.
 - 1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch- (6.35-mm-) diameter, hot-dip galvanized steel wire.
 - 2. Tie Section: Triangular-shaped wire tie made from 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized steel wire.
- D. Partition Top Anchors: 0.105-inch- (2.66-mm-) thick metal plate with a 3/8-inch- (9.5-mm-) diameter metal rod 6 inches (152 mm) long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from steel, hot-dip galvanized after fabrication.
- E. Rigid Anchors: Fabricate from steel bars 1-1/2 inches (38 mm) wide by 1/4 inch (6.35 mm) thick by 24 inches (610 mm) long, with ends turned up 2 inches (51 mm) or with cross pins unless otherwise indicated.
 - 1. Corrosion Protection: Hot-dip galvanized to comply with ASTM A153/A153M.

2.10 EMBEDDED FLASHING MATERIALS

- A. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:
 - 1. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.016 inch (0.40 mm) thick.
 - 2. Fabricate continuous flashings in sections 96 inches (2400 mm) long minimum, but not exceeding 12 feet (3.7 m). Provide splice plates at joints of formed, smooth metal flashing.
 - 3. Fabricate metal drip edges for ribbed metal flashing from plain metal flashing of same metal as ribbed flashing and extending at least 3 inches (76 mm) into wall with hemmed inner edge to receive ribbed flashing and form a hooked seam. Form hem on upper surface of metal so that completed seam sheds water.
 - 4. Fabricate metal drip edges from stainless steel. Extend at least 3 inches (76 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.
 - 5. Fabricate metal expansion-joint strips from stainless steel to shapes indicated.
 - 6. Solder metal items at corners.
- B. Single-Wythe CMU Flashing System: System of CMU cell flashing pans and interlocking CMU web covers made from UV-resistant, high-density polyethylene. Cell flashing pans have integral weep spouts designed to be built into mortar bed joints and that extend into the cell to prevent clogging with mortar.
- C. Solder and Sealants for Sheet Metal Flashings:
 - 1. Solder for Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.
- D. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

2.11 MISCELLANEOUS MASONRY ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene or urethane.
- B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

- C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D226/D226M, Type I (No. 15 asphalt felt).

2.12 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
 - 1. Do not use calcium chloride in mortar or grout.
 - 2. Use hydraulic blended cement mortar unless otherwise indicated.
 - 3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
- B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.
 - 1. For reinforced masonry, use Type S.
 - 2. For exterior, above-grade, load-bearing and nonload-bearing walls and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type S.
- D. Pigmented Mortar: Use colored cement product or select and proportion pigments with other ingredients to produce color required. Do not add pigments to colored cement products.
 - 1. Pigments does not exceed 10 percent of cement by weight.
 - 2. Application: Use pigmented mortar for exposed mortar joints with the following units:
 - a. Decorative CMUs.
- E. Grout for Unit Masonry: Comply with ASTM C476.
 - 1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
 - 2. Proportion grout in accordance with ASTM C476, Table 1 or paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi.

3. Provide grout with a slump of 8 to 11 inches (200 to 280 mm) as measured in accordance with ASTM C143/C143M.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 2. Verify that foundations are within tolerances specified.
 3. Verify that reinforcing dowels are properly placed.
 4. Verify that substrates are free of substances that would impair mortar bond.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Build chases and recesses to accommodate items specified in this and other Sections.
- B. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.
- C. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

3.03 TOLERANCES

- A. Dimensions and Locations of Elements:
 1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch (12 mm) or minus 1/4 inch (6 mm).
 2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch (12 mm).
 3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch (12 mm) total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.5 mm).

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (12 mm).
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm).

3.04 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.
- C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than 4 inches (100 mm). Bond and interlock each course of each wythe at corners. Do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.
- D. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- F. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.
- G. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.
- H. Fill cores in hollow CMUs with grout 24 inches (600 mm) under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- I. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.
 - 1. Install compressible filler in joint between top of partition and underside of structure above.
 - 2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors 48 inches (1200 mm) o.c. unless otherwise indicated.
 - 3. Wedge nonload-bearing partitions against structure above with small pieces of tile, slate, or metal. Fill joint with mortar after dead-load deflection of structure above approaches final position.
 - 4. At fire-rated partitions, treat joint between top of partition and underside of structure above to comply with Section 07 84 43.

3.05 MORTAR BEDDING AND JOINTING

- A. Lay hollow CMUs as follows:

1. Bed face shells in mortar and make head joints of depth equal to bed joints.
 2. Bed webs in mortar in all courses of piers, columns, and pilasters.
 3. Bed webs in mortar in grouted masonry, including starting course on footings.
 4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
- B. Set cast-stone trim units in full bed of mortar with full vertical joints. Fill dowel, anchor, and similar holes.
1. Clean soiled surfaces with fiber brush and soap powder and rinse thoroughly with clear water.
 2. Wet joint surfaces thoroughly before applying mortar.
 3. Rake out mortar joints for pointing with sealant.
- C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

3.06 MASONRY-CELL FILL INSTALLATION

- A. Install molded-polystyrene insulation units into masonry unit cells before laying units.

3.07 MASONRY-JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).
1. Space reinforcement not more than 16 inches (406 mm) o.c.
 2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.
 3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings in addition to continuous reinforcement.
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.
- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.
- E. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.08 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

- A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:
 - 1. Provide an open space not less than 1 inch (25 mm) wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
 - 2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
 - 3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (915 mm) o.c. horizontally.

3.09 CONTROL AND EXPANSION JOINTS

- A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.
- B. Form control joints in concrete masonry as follows:
 - 1. Fit bond-breaker strips into hollow contour in ends of CMUs on one side of control joint. Fill resultant core with grout and rake out joints in exposed faces for application of sealant.
 - 2. Install preformed control-joint gaskets designed to fit standard sash block.
 - 3. Install interlocking units designed for control joints. Install bond-breaker strips at joint. Keep head joints free and clear of mortar or rake out joint for application of sealant.
 - 4. Install temporary foam-plastic filler in head joints and remove filler when unit masonry is complete for application of sealant.

3.10 LINTELS

- A. Provide concrete or masonry lintels where shown and where openings of more than 12 inches (305 mm) for brick-size units and 24 inches (610 mm) for block-size units are shown without structural steel or other supporting lintels.
- B. Provide minimum bearing of 8 inches (200 mm) at each jamb unless otherwise indicated.

3.11 FLASHING

- A. General: Install embedded flashing at ledges and other obstructions to downward flow of water in wall where indicated.
- B. Install flashing as follows unless otherwise indicated:

1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.
 2. At lintels, extend flashing a minimum of 6 inches (150 mm) into masonry at each end. At heads and sills, extend flashing 6 inches (150 mm) at ends and turn up not less than 2 inches (50 mm) to form end dams.
 3. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 07 92 00 for application indicated.
 4. Install metal drip edges with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 07 92 00 for application indicated.
 5. Install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal drip edge.
 6. Cut flexible flashing off flush with face of wall after masonry wall construction is completed.
- C. Install single-wythe CMU flashing system in bed joints of CMU walls where indicated to comply with manufacturer's written instructions. Install CMU cell pans with upturned edges located below face shells and webs of CMUs above and with weep spouts aligned with face of wall. Install CMU web covers so that they cover upturned edges of CMU cell pans at CMU webs and extend from face shell to face shell.
- D. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.

3.12 REINFORCED UNIT MASONRY

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.

- B. Placing Reinforcement: Comply with requirements in TMS 602/ACI 530.1/ASCE 6.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
 - 1. Comply with requirements in TMS 602/ACI 530.1/ASCE 6 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
 - 2. Limit height of vertical grout pours to not more than 60 inches (1520 mm).

3.13 FIELD QUALITY CONTROL

- A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements is done at Contractor's expense.
- B. Inspections: Special inspections in accordance with Level 3 in TMS 402/ACI 530/ASCE 5.
 - 1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.
 - 2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.
 - 3. Place grout only after inspectors have verified proportions of site-prepared grout.
- C. Testing Prior to Construction: One set of tests.
- D. Testing Frequency: One set of tests for each 5000 sq. ft. (464 sq. m) of wall area or portion thereof.
- E. Concrete Masonry Unit Test: For each type of unit provided, in accordance with ASTM C140 for compressive strength.
- F. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, in accordance with ASTM C780.
- G. Mortar Test (Property Specification): For each mix provided, in accordance with ASTM C780. Test mortar for mortar air content and compressive strength.
- H. Grout Test (Compressive Strength): For each mix provided, in accordance with ASTM C1019.

3.14 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
 - 1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
 - 2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Engineer's approval of sample cleaning before proceeding with cleaning of masonry.
 - 3. Protect adjacent stone and nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
 - 4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
 - 5. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

END OF SECTION

SECTION 05 10 50

STRUCTURAL ALUMINUM

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide Structural aluminum products, including sheet, pipe, extrusions, and associated accessories as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - 2. B221: Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
 - 3. B308: Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles
- B. American Welding Society (AWS):
 - 1. A5.10: Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods
 - 2. D1.2: Structural Welding Code - Aluminum

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.
- C. Manufacturer's information and catalog data showing compliance with this specification and a full description of the product.
- D. Shop Drawings:
 - 1. Submit in advance of fabrication complete information necessary for the fabrication of each component and part of the structural aluminum. Including but not limited to the following:
 - a. Member size and length

- b. Bill of materials
 - c. Material specifications
 - d. Bolt hole size and bolt size
 - e. Cuts, copes, and bevels
 - f. Piece marks for field assembly
 - g. Detail of each connection or typical connection
 - h. Splices
2. Submit erection drawings showing complete information necessary for the erection of each component part of the structural aluminum. Including but not limited to the following:
- a. Dimensions for alignment and elevations of each member.
 - b. Location of members and attachments by match-marking of piece numbers.
 - c. Type and location of each field connection.
 - d. Number of shear connectors on each member.
 - e. Detail of each field connection or typical connection.
 - f. Anchor bolts and setting plans.
3. Do not develop shop drawings by using reproductions of contract drawings. Identify each shop drawing detail by contract drawing detail title.
4. Indicate shop welding and the required nondestructive testing by welding symbols and nondestructive testing symbols as shown in the latest edition of AWS A2.4.
- a. Fully explain special conditions with notes or details.
 - b. Welding symbols for groove welds shall indicate the groove depth required to obtain the specified effective throat thickness for the welding process and position of welding to be used.
 - c. The details of groove welds, joints, and preparation of base material shall be referenced to prequalified joints specified in AWS D1.2 and shall clearly distinguish between complete joint penetration and partial joint penetration.
5. Fillet weld symbols shall indicate required weld size to obtain the specified effective throat thickness and effective length. For fillet weld lengths not specified provide a continuous weld.

- E. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
 - F. Welder's certificates
- 1.04 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.05 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Qualifications:
 - 1. Perform welding of structural metals with welders who have a current AWS certificate for the type of welding to be performed.
 - 2. Remove welders performing unsatisfactory work, or require to requalify.
 - 3. Weld inspections may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
 - 4. Contractor shall bear costs of retests on defective welds.
 - 5. Contractor shall bear costs in connection with qualifying welders.

PART 2 - PRODUCTS

2.02 MATERIALS

- A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.
- B. Structural aluminum: ASTM B308, Alloy 6061-T6.
- C. Extruded aluminum: ASTM B221, Alloy 6063-T42.
- D. Isolating sleeves and washers:
 - 1. As indicated on the Drawings and as specified in Section 03 15 20.
- E. Miscellaneous Materials:
 - 1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.

2. Size, form, attachment, and location shall conform to the best of current practice.
3. Conform to applicable ASTM Standards for materials not otherwise specified.

2.03 FABRICATION:

A. Aluminum Layout:

1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.

B. Cutting Aluminum:

1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
2. Material more than 1/2-inch thick: Saw or rout.
3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
5. Do not flame cut aluminum alloys.
6. Punch or drill rivet or bolt holes to finished size before assembly:
 - a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
 - b. Make holes cylindrical and perpendicular to principal surface.
 - c. Do not permit holes to drift in a manner to distort metal.

C. Aluminum Forming and Assembly:

1. Do not heat structural aluminum, except as follows:
 - a. Heat aluminum to 400 degrees F for 30 minutes maximum, to facilitate bending or welding.
 - b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.

D. Before assembly, remove chips lodged between contacting surfaces.

E. Welding Aluminum:

1. Perform welding of aluminum in accordance with AWS D1.2.
2. Weld aluminum in accordance with the following:
 - a. Preparation:
 - (1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
 - (2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
 - (3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
 - (4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
 - b. Filler metal: Aluminum alloys conforming to the requirements of AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
 - c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
 - d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
 - e. Do not use welding process that requires use of a welding flux.
 - f. Neatly make welded closures.
 - g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
 - h. Make welds full penetration welds unless otherwise indicated on the Drawings.

2.04 FINISHES:

A. Coating for dissimilar metals:

1. Alkali resistant bitumastic:
 - a. Manufacturers: One of the following:

- (1) Carboline, Bitumastic Super Service Black.
 - (2) Tnemec, 46-465.
 - (3) Wasser, MC-Tar.
- b. Minimum dry film thickness of coating shall be 20-mils, applied as two 10-mils coats.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install structural aluminum products as indicated on the Drawings and as specified.
- B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
- C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
- D. Place anchor bolts or other anchoring devices accurately and make surfaces which bear against structural items are smooth and true to level.
- E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.
- F. Interface with other products:
 1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 03 15 20.
 2. Do not paint exposed aluminum surfaces. Remove markings and leave surfaces clean. Coat those parts of aluminum which will be cast into concrete, and those parts of aluminum which will come in contact with masonry, concrete, or wood, with an alkali resistant bitumastic coating as defined in Article 2.03.
 3. Coat those parts of aluminum which will be cast into concrete or which will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, with an alkali resistant bitumastic coating as defined in Article 2.04.

3.02 EXAMINATION:

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.03 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 12 00
STRUCTURAL STEEL

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. The term "Structural Steel" is used as defined in accordance with the AISC Code of Standard Practice.
- B. Provide structural steel as specified and as shown on contract drawings.

1.02 REFERENCES:

- A. American Institute of Steel Construction (AISC):
 - 1. 303: Code of Standard Practice for Steel Buildings and Bridges
 - 2. 325: Manual of Steel Construction, Fifteenth Edition
 - 3. 326: Structural Steel Detailing Manual
 - 4. 348: Specification for Structural Joints using ASTM A325 or A490 Bolts
 - 5. 360-16: Specification for Structural Steel Buildings
- B. ASTM International (ASTM):
 - 1. A6: Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
 - 2. A36: Specification for Carbon Structural Steel.
 - 3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 4. A108: Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished
 - 5. A123: Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 6. A143: Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedures for Detecting Embrittlement.
 - 7. A153: Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

8. A194: Specification for Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
9. A307: Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
10. A384: Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
11. A385: Practice for Providing High Quality Zinc Coatings (Hot-Dip).
12. A449: Specification for Quenched and Tempered Steel Bolts and Studs.
13. A500: Standard Specification for Steel for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
14. A563: Specification for Carbon and Alloy Steel Nuts.
15. A572: Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
16. A780: Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
17. A992: Standard Specification for Steel for Structural Shapes for Use in Building Framing.
18. B695: Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
19. F436: Specification for Hardened Steel Washers.
20. F1554: Standard Specification For Anchor Bolts, Steel, 36, 55, and 105 ksi Yield.
21. F3125: Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

C. American Welding Society (AWS):

1. D1.1: Structural Welding Code – Steel

D. Occupational Safety and Health Administration (OSHA):

1. Safety and Health Standards for the Construction Industry, 29 CFR 1926 Subpart R Safety Standards for Steel Erection.

E. Governing Building Code:

1. International Building Code (IBC).

1.03 DESIGN CRITERIA:

- A. Structural Connections: AISC Specification for Structural Steel Buildings. Design connections not fully detailed on the Drawings to resist the loads shown on the Contract Drawings or specified.
- B. Where beam end reactions are not shown, design the connection for one-half the total allowable uniform load in kips for beams laterally supported at the given span, as determined by the tables for allowable loads on beams in the AISC Manual of Steel Construction, in addition to any axial loads identified on the Drawings.
- C. Unless otherwise noted on Contract Drawings, design connections for ASTM F3215 bolts, bearing-type connection with threads included in shear plane.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 1. Submit in advance of fabrication complete information necessary for the fabrication of each component and part of the structural steel framing. Include the following:
 - a. Member size and length.
 - b. Bill of materials.
 - c. Material specifications.
 - d. Bolt hole size and bolt size.
 - e. Cuts, copes, and bevels.
 - f. Piece marks for field assembly.
 - g. Detail of each connection or typical connection.
 - h. Splices.
 2. Submit erection drawings showing complete information necessary for the erection of each component part of the structural steel framing. Include the following:
 - a. Dimensions for alignment and elevations of each member.
 - b. Location of members and attachments by match-marking of piece numbers.

- c. Type and location of each field connection.
 - d. Number of shear connectors on each member.
 - e. Detail of each field connection or typical connection.
 - f. Anchor bolts and setting plans.
- 3. Do not develop shop drawings by using reproductions of contract drawings. Identify each shop drawing detail by contract drawing detail title.
- 4. Indicate both shop and field welding and the required nondestructive testing by welding symbols and nondestructive testing symbols as shown in the latest edition of AWS A2.4.
 - a. Fully explain special conditions with notes or details.
 - b. Welding symbols for groove welds shall indicate the groove depth required to obtain the specified effective throat thickness for the welding process and position of welding to be used.
 - c. The details of groove welds, joints, and preparation of base material shall be referenced to prequalified joints specified in AWS Figures 3.2 through 3.11 and shall clearly distinguish between complete joint penetration and partial joint penetration.
 - d. Fillet weld symbols shall indicate required weld size to obtain the specified effective throat thickness and effective length. For fillet weld lengths not specified provide a continuous weld.
- 5. Welding Procedures: Prepare written welding procedures for both shop and field welds, which are deemed prequalified in accordance with AWS Code Section 3 and make the procedures available to the testing agency at the fabricator's plant. Prior to use of submit other for review procedures along with tests required to qualify the procedure in accordance with AWS Code Section 3.2.3.
- 6. Submit sequence-of-welding outline.
- 7. Submittals for Evidence of Conformity to Specifications: Certified mill test reports containing results of chemical and mechanical test as specified by ASTM A6 for the following material:
 - a. Structural steel shapes
 - b. Structural steel bars
 - c. Structural steel plates

In addition to the certified mill test reports, the fabricator shall provide an affidavit stating that the structural steel furnished meets the requirements of ASTM specification for the grade furnished. Test any of the members not represented by certified mill test reports by the testing laboratory in accordance with ASTM specification for chemical and physical properties. The contractor is responsible for the cost of sampling and testing.

8. Submit manufacturer's certification and test data that the following items furnished conform to the following specifications:
 - a. High-strength bolts including nuts and washers. Provide Connection type N per the AISC handbook unless otherwise noted in the drawings.
9. Proposed Substitutions: Submit for review in sketch form prior to submittal of shop drawings substitutions of members or modifications of details, if proposed by the Contractor. Submit in sketch form for review corrections for inaccuracy that result in a change from the structural drawing or final shop drawing details. Make such substitutions or corrections only when permitted by the Engineer.
10. Qualification test reports bearing witness certification by an independent testing laboratory for each welder, welding operator and tacker to be employed in the work.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Test and inspect structural steel in accordance with Section 01 45 33.
- C. Provide structural steel in accordance with AISC Standard for Structural Steel Buildings and the Code of Standard Practice for Steel Buildings and Bridges, unless otherwise specified herein.
- D. Use connections shown or, if not shown, select connections to support half the AISC maximum uniform load for the indicated beam size and span.
- E. Steel fabricator shall have 5 years' experience minimum in structural steel fabrications.
- F. Steel erector shall have 5 years' experience minimum in structural steel erection.
- G. Welding Qualification and Certification:
 1. Furnish written welding procedure for welds in conformance with the AWS D1.1.
 2. Each welder, welding operator and tack welder shall be certified by test to perform type of work required in conformance with AWS D1.1.

3. If a welder or welding operator has not been engaged in a specific welding process for a period of six months or more, that individual shall be deemed unqualified and shall not perform work on the project until the individual has been qualified again by testing in conformance with AWS D1.1.
4. Maintain duplicate qualification and certification records at the job site readily available for examination.

H. Tolerances:

1. Maintain tolerances conforming to AISC Code of Standard Practice.
2. Permissible variation tolerances conforming to ASTM A6.

I. Tension Calibrator:

1. Provide certification by an independent testing laboratory confirming the accuracy of the tension-measuring device when slip-critical connections and connections subject to direct tension are being used. Confirm accuracy not more than 30 days prior to use on project and at intervals not more than six months thereafter.
2. Provide tension calibrator measuring device at the job site when high-strength bolts in slip-critical connections and connections subject to direct tension are being installed and tightened.
3. Conform to the AISC Specification for Structural Joints for frequency and of number confirmation tests to be performed and the test procedure.
4. Return tension calibrator measuring device to the independent testing laboratory for certification if Engineer questions its accuracy.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements in Section 01 61 00.
- B. Load structural members in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.
- C. Protect structural steel members and packaged materials from corrosion and deterioration. Store material in a dry area.
- D. Support materials stored outdoors above ground surfaces on wood runners and protected with acceptable effective and durable covers.
- E. Do not place materials on the structure in a manner that might cause distortion or damage to the members or the supporting structures. Repair or replace damaged materials or structures as recommended by the Engineer.

1.07 FIELD MEASUREMENTS:

- A. Verify dimensions and make any field measurements necessary and be fully responsible for accuracy and layout of the work.
- B. Review the Contract Drawings and report any discrepancies to the Engineer for clarification prior to starting fabrication.

PART 2 - PRODUCTS

2.01 STRUCTURAL STEEL:

- A. W shapes in conformance with ASTM A992 unless otherwise indicated or specified.
- B. C, M, S and HP shapes in conformance with ASTM A572, Grade 50, unless otherwise specified or shown on contract drawings.
- C. Angles, plates and bars in conformance with ASTM A36.
- D. Round, square and rectangular structural tube members (HSS) in conformance with ASTM A500, Grade C.
- E. Steel pipe in conformance with ASTM A53, Grade B.
- F. Hot-Dip Galvanized Carbon Steel in conformance with ASTM A123.

2.02 FASTENERS:

- A. Carbon Steel Bolts, Nuts and Washers: ASTM A307, Grade A.
- B. High-strength fasteners in conformance with ASTM F3125, Type 1.
- C. Nuts and washers ASTM A563 and F 436.
- D. Hot-dip Galvanized Bolts, nuts and washers in conformance with ASTM A153.
- E. Mechanically Galvanized Bolts, nuts and washers in conformance with ASTM B695.

2.03 ANCHOR BOLTS:

- A. Steel anchor bolts in conformance with ASTM F1554, Grade 36.

2.04 CRANE RAILS:

- A. Provide in conformance with crane manufacturer's requirements and as indicated or specified. Provide materials needed for fabrication and construction of crane rails, including:
 - 1. Joint bar bolts: ASTM A449 or ASTM F3125
 - 2. Joint bar nuts: ASTM A563, Grade B or ASTM F3125

2.05 WELDING:

- A. Class E70XX electrodes
- B. Provide equipment for welding, electrodes, welding wire and fluxes capable of producing indicated welds when used by certified welders under AWS welding procedures. Provide welding materials that comply with requirements of AWS Structural Welding Code.

2.06 SHOP FABRICATION:

- A. Fabricate each element and connection as indicated on the fabrication shop drawings accepted by the Engineer. Fabricate and shop assemble work to the greatest extent practical in conformance with following publications:
 - 1. AISC Manual of Steel Construction
 - 2. AISC Specification for Structural Joints
 - 3. AISC Detailing Manual
 - 4. AWS Structural Welding Code

2.07 CONNECTIONS:

- A. Connect members with ASTM F3125 high strength bolts unless otherwise specified or shown on contract drawings. Provide clean-cut holes without torn or ragged edges and remove outside burrs.
- B. Provide high-strength bolted construction assembly in accordance with AISC Specifications for Structural Joints. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Free joint surfaces burrs and foreign materials. Score hot-dipped galvanized contact surfaces with a wire brush or blasted prior to assembly. Grinding of surfaces is not permitted. If the thickness of the material is not greater than the normal diameter of the bolt plus 1/8 inch, the holes may be punched. If the thickness of the material is greater than the normal diameter of the bolt plus 1/8 inch, drill it full size or subpunched 1/16 inch smaller than the bolt diameter and reamed to full size. Provide holes for work

to be secured to structural steel framing and for the passage of work through steel framing members. Provide threaded nuts, threaded units, or other items welded to framing, which receive other work. Provide normal bolt hole diameters not more than 1/16 inch in excess of the normal bolt diameter unless otherwise specified in contract drawings. Provide required slotted or oversize bolt holes as specified in the AISC Specification for Structural Joints Section 3.3. Tighten each bolt to provide the minimum tension shown in Table 8.1 of AISC Specification for Structural Joints for the size and grade of bolts used. Tighten bolts in accordance with the manufacturer's specifications.

- C. Provide full cross section bearing on milled ends of columns, crane rails, monorails, and bearing stiffeners.
- D. Welded Connections:
 - 1. Weld connections indicated or specified.
- E. Make connections with ASTM A307 carbon steel bolts when specified or shown in contract drawings.
- F. Provide anchor rods with washer and heavy hex nuts. Provide hot-dip galvanized anchor rods, washers and heavy hex nuts with galvanized steel.

2.08 GALVANIZE:

- A. Provide hot-dip galvanizing in conformance with ASTM A123, Grade 100 to steel indicated or specified to be galvanize coated in the Drawings.
- B. Provide hot-dip galvanizing, in conformance with ASTM A153, to bolts, nuts and washers that will be used with galvanized steel.
- C. Complete fabrication and prepare surfaces of steel by removing weld spatter, flux, residue, burrs and metal surface defects before galvanizing. Clean weldments with power wire brush prior to galvanizing.
- D. Provide steel dipped into solution of zinc chloride plus ammonium chloride immediately prior to galvanizing.
- E. Tap bolt nuts after hot-dip galvanizing in conformance with ASTM A563.
- F. Inspect galvanized material for compliance with these specifications. Mark the material with a clearly visible stamp indicating the name of the galvanizer, the ASTM number and the weight of zinc coating in ounces per sq. ft.

2.09 GALVANIZE TOUCH-UP:

- A. Galvanize Touch-Up: Where galvanizing is damaged, touch-up abraded areas, using brushed-on method, with zinc-rich coating. Touch-up repair with zinc-rich coating of not less than 3 mil and not more than 6 mil dry film thickness.

- B. Touch-up damaged galvanized surfaces with one of the following zinc rich coatings:
 - 1. Endupor, zinc-rich coating by Dampney Manufacturing Co., Everett, MA
 - 2. ZiRP, zinc-rich coating by Duncan Galvanizing Corp., Everett, MA
 - 3. ZRC Cold Galvanizing Compound or ZRC Galvilite by ZRC Worldwide, Division of Norfolk Corp., Marshfield, MA

PART 3 - EXECUTION

3.01 ERECTION OF STRUCTURAL STEEL:

- A. Conform to the IBC and referenced AISC standards. Brace and secure work until permanent connections are completed. Provide accessories and fasteners to secure the work in place whether or not shown or specified. Comply with OSHA requirements.
- B. Erect structural steel with qualified, experienced personnel. Plan and lay out steel to require minimum of cutting. Erect work plumb, square, and true to line and level and in precise positions. Provide temporary bracing and guys to counteract loads and stresses to which structure may be subjected, including those due to erection equipment and its operation. Do not encumber premises with material or equipment.
- C. Splice members only where shown or specified. On exposed welded connections, remove erection bolts, fill holes with plug welds, and grind smooth at exposed surfaces. Comply with AISC specifications for bearing, adequacy of temporary connections, alignment, and the removal of paint on surfaces adjacent to field welds. Do not enlarge holes in members by burning or the use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to place bolts. Do not use gas-cutting torches in the field for correcting fabrication errors in the structural framing.
- D. Erect, plumb, level, and align each individual member within the tolerance defined in Section 7 and Commentary of the AISC Code of Standard Practice, allowing for weld shrinkage during erection for assurance that the end product is within specified tolerance. Establish and maintain the building line for use in plumbing the exterior columns.

3.02 DAMAGED MEMBERS:

- A. During erection, straighten or replace members that are bent, twisted, or damaged. If heating is required in straightening, perform heating by methods that ensure uniform temperature throughout entire member. When required by the Engineer, remove members that are impaired strength and replace with new members at no additional cost to Owner.

3.03 MISFITS AT BOLTED CONNECTIONS:

- A. Immediately notify the Engineer where misfits in erection bolting are encountered. The Submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.
- B. Do not enlarge incorrectly sized or misaligned holes in members by burning or by the use of drift pins. Notify the Engineer immediately and submit a proposed method of remedy for review by the Engineer.

3.04 ANCHOR BOLTS:

- A. Install anchor bolts by using templates, setting drawings, and instructions provided by the fabricator. Verify positions of bolts prior to delivery of steel; report errors or deviation for adjustment. After anchor bolts have been embedded, protect threads by applying grease and by having the nuts screwed on until the metalwork is installed.

3.05 COLUMN BASEPLATES AND BEARING PLATES:

- A. Set columns with base plates attached and bearing plates for beams and similar structural members to their proper alignment and elevation using shim packs. Set loose column bases level to their proper alignment and elevation by use of shim packs or as shown in the contract drawings. Tighten anchor bolts after members have been positioned and plumbed. Do not remove protruding wedges, shims, or other leveling devices but cut off flush with the baseplate prior to packing with grout.

3.06 CONNECTIONS:

- A. Securely bolt members to maintain steel in position during field welding and final bolting and accommodate dead loads, wind, and erection stresses.
- B. Tighten high-strength bolted connections in accordance with AISC Specification for Structural Joints using ASTM F3125 Bolts and manufacturer's specifications.
- C. Perform shop-welded construction in accordance with AWS D1.1 Sections 2 through 6, whichever is applicable. Use only welded joints deemed as being prequalified in accordance with AWS Code Section 4, which are selected from AWS Code Figures 3.2 through 3.11.
- D. Common Bolts: Tighten ASTM A307 and nonslip critical bolts to snug tight plus one-quarter turn with upset bolt threads to preclude loosening, or use self-locking nuts.
- E. Do not reuse galvanized high-strength bolts, nuts and washers.

3.07 CRANE RAILS:

- A. Installation: Provide in conformance with crane manufacturer's printed instructions and as specified or as shown on contract drawings.

- B. Fasten crane rails to runway beam with rail clamps, in pairs, one each side of rail, spaced not more than 30 inch centers. Bolt each clamp to runway beam top flange with two bolts and self-locking nuts. Allow 1/32-inch clearance between clamp plate and top of rail flange and 1/4-inch clearance between clamp plate and edge of rail flange to provide a "floating rail" in conformance with AISC Manual. Do not use hook bolts. Center crane rail on the runway beam. In no case shall the crane rail eccentricity be greater than three-fourths of the runway beam web thickness. The entire assembly will be rejected if the crane rail eccentricity exceeds the three-fourths limitation. Replace and remove entire rejected assembly from job site at no additional cost to the Owner.
 - C. Install crane rails with milled ends and tight joints at splices. Use bolted splice bars to maintain joint alignment in conformance with AISC Manual. Do not use welded butt joints.
 - D. Retighten splice bolts within 30 days and in conformance with AISC Manual.
- 3.08 CLEAN-UP:
- A. Upon completion of the work, remove surplus materials, rubbish, and debris resulting from the operations, including disused equipment and implements of service, and leave the entire structure and site, insofar as the work of this section is concerned, in a neat, clean condition.
- 3.09 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 21 00

STEEL JOISTS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide open web steel joists and long span steel joists as indicated and in compliance with Contract Documents.
- B. Provide bridging in accordance with the SJI, OSHA requirements and as indicated and in compliance with Contract Documents.
- C. Provide accessories in accordance with SJI requirements.

1.02 REFERENCES:

- A. American Institute of Steel Construction (AISC):
 - 1. 303: Code of Standard Practice for Steel Buildings and Bridges.
 - 2. 325: Manual of Steel Construction, Allowable Stress Design.
 - 3. 326: Detailing for Steel Construction.
 - 4. 348: Specification for Structural Joints using ASTM A325 or A490 Bolts.
- B. ASTM International (ASTM):
 - 1. A307: Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - 2. A384: Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
 - 3. A385: Practice for Providing High Quality Zinc Coatings (Hot-Dip).
 - 4. A449: Specification for Quenched and Tempered Steel Bolts and Studs.
 - 5. F3125: Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- C. American Welding Society (AWS):
 - 1. D1.1: Structural Welding Code – Steel.

D. Occupational Safety and Health Administration (OSHA):

1. Steel Erection Standard 29 CFR 1926.757.

E. Steel Joist Institute (SJI):

1. OWS: Open Web Steel Joists, K-Series.
2. SJI Load Tables:
 - a. Standard Specifications for Open Web Steel Joists, K-Series.
 - b. Code of Standard Practice for Steel Joists and Joist Girders.
3. TD9: Handling and Erection of Steel Joists and Joist Girders.

F. Steel Structures Painting Council (SSPC):

1. SP15: Commercial Grade Power Tool Cleaning.

1.03 DESIGN CRITERIA:

- A. Design joists for the dead loads based on floor and roof systems shown on the Contract Documents.
- B. Design joists for the live loads plus any special loads shown on the Contract Documents.
- C. Design joists for an additional superimposed load to account for piping, sprinklers, electrical conduit and components, equipment and ductwork. Design for a minimum of 20 psf or the actual weight of the items above.
- D. Design joists and connections for a net uplift of 20 psf unless otherwise indicated on the Contract Documents.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 1. Complete and checked shop and erection drawings for steel joists and components.
 - a. Indicate standard designations, number, sizes, lengths, spacing and locations of joists, camber, bridging, connections, bearing plates, attachments and top and bottom chord extensions.
 - b. Shop and erection drawings for steel joists shall be reviewed by Engineer prior to fabrication.
 - c. Mill and material certifications.

- B. Certification, signed and sealed by a Professional Engineer employed by the joist manufacturer and registered in the State where the joists will be installed, indicating the codes and specifications to which the joist design conforms and stating that members, elements and connections are designed to withstand the specified loads.
- C. Qualification test reports bearing witness certification by an independent testing laboratory for each welder, welding operator and tacker to be employed in the work.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Design joists and connections for the loads, moments and chord forces indicated on the Contract Documents.
- C. Allowable deflection for steel joists shall be $L/240$ of clear span under indicated uniform live load.
- D. Steel joist design, manufacture, handling and installation shall conform to the AISC and SJI Standard Specifications and load and weight tables.
- E. Bridging size and installation shall be as prescribed by the SJI.
- F. Provide special joists where required to carry concentrated or other special loads.
- G. Steel joists shall be SJI approved.
- H. Each welder, welding operator and tack welder shall be certified by test to perform type of work required in conformance with the SJI and AWS D1.1.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 61 00.
- B. Storage and handling shall conform to the SJI Technical Digest #9.
- C. Transport, handle and store materials to protect from weather, rusting, corrosion or other damage.
- D. Store joists on substantial timbers and blocking with webs of joists vertical. Cover and protect from snow, rain and ground splatter
- E. Deliver, store and handle in a manner that prevents overstressing, deformation or damage.
- F. Prevent damage to shop coat.

PART 2 - PRODUCTS

2.01 STEEL JOISTS:

- A. Fabricate steel joists in accordance with the shop drawings, AISC, and the SJI standard specifications.
- B. Provide top and bottom chord extensions as shown on Contract Drawings. Top chord extensions shall be Type R.
- C. Provide sloped bearing ends where joist slope exceeds 1/4-inch per foot (0.5 percent).
- D. Provide bearing lengths in accordance with the SJI unless greater bearing lengths are indicated on the Contract Documents.
- E. Joist Seats:
 - 1. Seats for K-Series joists shall be 2-1/2 inches in depth and shall extend a minimum of 2-1/2 inches over steel supports, except as noted on the drawings.
 - 2. Seats for LH-Series and DLH-Series joists shall be 5 inches (125 mm) in depth and shall extend a minimum of 4 inches (100 mm) over steel supports.
 - 3. Fabricate with special seats as shown on shop drawings.
- F. Provide additional web members at points of application of concentrated loads to transfer loads to panel points.

2.02 JOIST BRIDGING:

- A. Provide bridging and bridging anchorage in accordance with the SJI and OSHA, Steel Erection Standard 29 CFR 1926.757 requirements.
- B. Provide cross bridging between the last two joists at the end of a bridging line such as at end walls or expansion joints.
- C. Provide a line of bridging near each of the first bottom chord panel points for joists subjected to uplift.
- D. Provide bridging to brace the top chord of joists supporting standing seam roofing under gravity loads.
- E. Minimum bridging shall be provided as required and where indicated on the Contract Documents
- F. Manufacturer of joists shall furnish bridging and bridging anchorage.

2.03 CONNECTIONS:

- A. Provide bolted connections using ASTM A325 bolts.
- B. Provide welded connections in conformance with the AISC, SJI, and AWS.

2.04 SHOP PAINTING:

- A. Provide shop painting in accordance with Section 09 96 00.
- B. Remove loose scale, rust or other foreign materials from fabricated joists and accessories.

PART 3 - EXECUTION

3.01 PREPARATION:

- A. Coordinate placement of anchorages in concrete and masonry construction for securing bearing plates, angles and bridging anchors.
- B. Verify that completed construction is ready for and will support steel joist and joist girder placement.
- C. Notify the Engineer if discrepancies are found. Do not proceed or install joists and joist girders in areas of discrepancy until those discrepancies have been fully resolved.

3.02 JOISTS:

- A. Steel joist erection shall comply with AISC, SJI, and OSHA, Steel Erection Standard 29 CFR 1926.757.
- B. Install in accordance with the SJI specifications, manufacturer's printed instructions and as indicated and specified.
- C. Install in straight parallel lines at spacing indicated within a tolerance of 1/4-inch plus or minus.
- D. Secure by welding to steel support beams or steel bearing plates.
- E. Do not apply loads to joists until secured in place and bridging is installed and anchored at its ends.
- F. Do not use damaged joists. Replacement joists shall be furnished at Contractor's expense.

3.03 BRIDGING:

- A. Bridging and bridging anchorage shall be provided in accordance with the SJI instructions and OSHA, Steel Erection Standard 29 CFR 1926.757 requirements.

3.04 FIELD BOLTED CONNECTIONS:

- A. Provide bolted connections between joist and columns that are not braced in at least two directions by structural steel members.

3.05 FIELD WELDING:

- A. Perform field welding in accordance with the AWS D1.1, SJI and shop drawings.
- B. No field welding will be permitted unless indicated on shop drawings.

3.06 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 31 00

STEEL DECK

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide steel deck as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 318: Building Code Requirements for Structural Concrete
- B. American Iron and Steel Institute (AISI):
 - 1. Specifications for the Design of Cold-Formed Steel Structural Members
- C. ASTM International (ASTM):
 - 1. A611: Standard Specification for Steel, Sheet, Carbon, Cold-Rolled Structural Quality
 - 2. A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 3. A780: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- D. American Welding Society (AWS):
 - 1. D1.3: Structural Welding Code - Sheet Steel
- E. Factory Mutual Engineering Corporation (FM):
 - 1. 1-28: Loss Prevention Data
- F. Steel Deck Institute (SDI):
 - 1. Publication No. 23: Design Manual for Floor Decks and Roof Decks
 - 2. Publication No. 29: Design Manual for Composite Decks, Form Decks, Roof Decks and Cellular Deck Floor Systems with Electrical Distribution

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Submit complete manufacturer's specifications and installation instructions. Include manufacturer's certification showing compliance with these specifications.
 - 2. Submit detailed shop drawings showing layout of steel deck panels, anchorage details, openings, and every condition requiring closure panels, supplementary framing, special jointing, deck reinforcement, support locations or other accessories. Include professional structural engineer stamp on drawings for steel deck.
 - 3. Submit manufacturer's literature indicating steel deck load capacity for various deck styles, gages, spans and depth indicated or specified.
 - 4. Submit product data for mechanical fasteners to be used.
 - 5. Submit qualification test reports bearing witness certification by an independent testing laboratory for each welder and welding operator to be employed in the work

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Comply with the current editions of codes and regulations including current editions or revisions and supplements of the following relevant reference standards:
 - 1. IBC
 - 2. AISI "Specifications for the Design of Cold-Formed Steel Structural Members."
 - 3. AWS D1.3, "Structural Welding Code – Sheet Steel."
 - 4. SDI "Design Manual for Floor Decks and Roof Decks" and "Design Manual for Composite Decks, Form Decks, Roof Decks and Cellular Deck Floor Systems with Electrical Distribution."
- C. Qualifications of Erector: The erector shall have at least three years' experience in the erection of steel decking.
- D. Qualifications of Welding:
 - 1. Qualify welding processes and welding operators in accordance with AWS D1.3.
 - 2. Decking welded in place, is subject to inspection and testing. When welds are found defective, pay for testing and removal and replacing that portion of decking.

- E. Replace or repair damaged galvanized material as recommended by the Engineer.

1.05 DESIGN CRITERIA:

- A. Compute section properties of steel deck in conformance with AISI Specification for the Design of Cold-Formed Steel Structural Members.
- B. Material and steel deck profiles shall conform to the applicable requirements of the Steel Deck Institute specifications.
- C. Steel roof deck shall be capable of supporting all superimposed dead load and the live load shown on contract drawings with a maximum fiber stress in the deck of 20,000 psi. Superimposed dead loads and all loads to be suspended from the decking shall be accounted for in the design of the deck units.
- D. Anchor steel deck to the supporting members to resist an uplift of 45 psf for eave overhangs and 30 psf for all other roof areas unless noted otherwise on contract drawings.
- E. Maximum allowable deflection of roof deck under live load shall not exceed $L/240$ of the span.
- F. Steel deck shall be capable of supporting a construction load of 200 pounds distributed over a 1 foot width at midspans and at the ends of cantilevers with a maximum fiber stress of 26,000 psi and a maximum deflection of $L/240$.
- G. Steel floor deck shall be capable of supporting the dead load and live load indicated compositely with concrete with a maximum fiber stress in the deck of 20,000 psi. Superimposed dead loads and all loads to be suspended from the decking shall be accounted for in the design of the deck units.
- H. Steel floor deck shall be capable of supporting the weight of wet concrete without the need for temporary shoring during concrete placement.
- I. Maximum allowable deflection of composite floor deck under live load shall not exceed $L/360$ of the span.
- J. Design deck to account for construction loads as determined by the Steel Deck Institute construction loading criteria. As a minimum, the steel floor deck shall be capable of supporting the combined weight of the deck, the wet concrete and a 20 psf uniform load or 150 pound concentrated load over a 1 foot width at mid-spans and at the ends of cantilevers with a maximum fiber stress of 21,600 psi and a maximum deflection of $L/180$ or 3/4-inch relative to the supporting members.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 61 00.

- B. During loading, transporting, and unloading prevent damage and injury to ends, sides, and faces of panels.
- C. When delivered to the jobsite, store the steel decking off the ground and cover to protect material from the elements. Slope to permit drainage.

PART 2 - PRODUCTS

2.01 STEEL ROOF DECK:

- A. Steel roof decking type, depth and thickness shall be shown on contract drawings, but not less than 20 gage (0.034 inches).
- B. Form steel roof decking from steel conforming to ASTM A653 Structural Quality.
- C. Galvanize steel roof panels in accordance with ASTM A653, Coating Designation G-90.
- D. Steel roof deck is designed for 3-span condition. If less spans are used, notify Engineer.

2.02 STEEL FLOOR DECK:

- A. Steel floor decking type, depth and thickness shall be as shown on contract drawings but not less than 20 gage (0.034 inches).
- B. Whenever possible, deck shall be multi-span and shall not require shoring during the concrete placement procedure.
 - 1. Concrete: 3,000 psi at 28 days conforming to Section 03 30 00.
- C. Where fire resistance rated assemblies are required, provide UL-listed units. Identify steel deck bundles with labels bearing the UL mark.

2.03 ACCESSORIES:

- A. Provide ridge plates, valley plates, closures, flashing and sump pans manufactured from galvanized steel sheet conforming to the requirements of ASTM A653, structural quality, with a minimum yield stress of 33,000 psi and G90 coating.
 - 1. Ridge plates, valley plates, flat plates at changes in deck direction, closures, accessories and flashings: 18 gage
 - 2. Sump Pans: Flat, recessed, 14 gage
 - 3. Welding Washers: 16 gage

2.04 WELDING ELECTRODE:

- A. Use E60XX or higher welding electrodes.

2.05 FABRICATION:

- A. Form deck units in lengths to span three or more support spacings with flush, telescoped, or nested 2-inch end laps and nesting side laps, unless otherwise shown or specified. Laps shall be made over supports. Provide deck configurations complying with SDI "Basic Design Specifications."
- B. Fabricate roof sump pans from a single piece of galvanized sheet steel of the same quality as the deck units; with level bottoms and sloping sides to direct water flow to the drain, unless otherwise shown. Provide sump pans to receive roof drains and with bearing flanges not less than 3 inches wide. Recess pans to less than 1-1/2 inches below the roof deck surface, unless otherwise shown or required by deck configuration.
- C. Fabricate metal closure strips of galvanized sheet steel of the same quality as the deck units. Form to the configuration required to provide tight-fitting closures at open ends and sides of decking.
- D. Provide decking accessories, including closures and filler strips. Provide closure plates and other attachments at openings through decking for ducts, shafts, and other penetrations. Where decking changes directions and at perimeter, closures shall be of galvanized sheet steel of the same quality as the deck units unless otherwise indicated.
- E. Provide special width panels to result in continuous bearing of the deck on supports that are parallel to the deck ribs. Such bearing is required at the edge of the deck, supporting walls below the deck, and at deck openings.
- F. Provide special width panels, beam filler panels, or split panels at flanges of structural steel beam supports which are parallel to the deck ribs and which will have steel connectors attached to the beam flange.

PART 3 - EXECUTION

3.01 PREPARATION:

- A. Check supporting elements for correct layout and alignment. Correct any deficiencies before securing deck units.
- B. Remove debris from surfaces to support steel deck.

3.02 INSTALLATION:

- A. Install decking and accessories on structural supports in conformance with Steel Deck Institute specifications, the Steel Deck Institute Manual of Construction with Steel Deck, in accordance with placement plans, and as indicated and specified.
- B. Place steel decking with edges up and flutes at right angles to supports. End laps shall always occur over supports, with a minimum end lap of 2-inch for attachment.

- C. Begin placement of steel decking panels at corner of building to maintain alignment. Lap sheets one-half flute at side laps. Attach sheets to top chord of supports by plug weldings. Fasten each end lap in the trough of the flutes at each corner (through four thicknesses of metal) and at center of end lap. Limit the spacing between adjacent points of attachment to 18 inches maximum over supports.

- D. Permanently fasten deck panels to the structural supports immediately after placement.

3.03 WELDED ATTACHMENT:

- A. Anchor decking to supporting members with puddle welds in accordance with the attachment pattern shown on the shop drawings.

3.04 CUTTING AND FITTING:

- A. Perform all cutting and fitting of units.
- B. Do not make holes that are not indicated on manufacturer's shop drawings without prior written permission of Engineer.

3.05 ACCESSORIES:

- A. Provide flashing, ridge and valley plates; sump pans and other accessories necessary. Install sump pan at each roof drain.
- B. Close open ends of cell runs with cell closures at columns, openings, walls, etc. and ends where cells change direction.
- C. Provide and weld flashings into position to close openings between steel deck units and columns, beams and girders.
- D. Provide other closures and flashings required and as recommended by deck manufacturer.
- E. Fasten all closures, flashings and sump pans by tack welding at a maximum spacing of 24-inches on center, but not less than one weldment on each corner.
- F. Provide special end and side closures at spandrels and openings to act as edging.

3.06 REPAIR OF ZINC COATINGS:

- A. Clean weldments by chipping or wire brushing to remove all slag immediately prior to applying galvanized touch-up.
- B. Clean with wire brush and prime coat all cut edges with galvanized touch-up as specified herein.
- C. Apply galvanize touch-up immediately upon completion of cleaning weldments, abraded and damaged areas. Conform to the following requirements:

1. Galvanize Touch-Up: Where galvanizing is damaged, touch-up abraded areas, using brushed-on method, with zinc-rich coating. Touch-up repair with zinc-rich coating of not less than 3 mil and not more than 6 mil dry fil thickness.
2. Repair galvanizing using paints containing zinc dust in conformance with ASTM A780.

D. Materials:

1. Dampney Manufacturing Co.; Epodur 1870
2. Duncan Galvanizing Corp.; ZiRP
3. ZRC Worldwide, Division of Norfolk Corp.; ZRC Cold Galvanizing Compound or ZRC Galviline

3.07 CLEANING:

- A. Remove oil, grease, dirt and debris from deck and leave ready for work of next trade.

3.08 PROTECTION:

- A. Do not use deck units for storage or working platforms until permanently secured in position.
- B. Assure that construction loads do not exceed carrying capacity of deck.

3.09 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 40 10

COLD-FORMED STEEL FRAMING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide cold-formed steel stud and joist systems, design, connections, bracing, fasteners, and related accessories as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American National Standards Institute (ANSI):

- 1. A117.1: Accessible and Usable Buildings and Facilities.

- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

- 1. 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

- 2. 62.1: Ventilation for Acceptable Indoor Air Quality

- C. American Society of Mechanical Engineers (ASME):

- 1. B16.1: Pipe Flanges and Fittings

- 2. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

- 3. B16.10: Face-to-Face and End-to-End Dimensions of Valves

- 4. B16.34: Valves – Flanged, Threaded, and Welding End

- 5. B31.1: Power Piping

- 6. B31.9: Building Services Piping.

- D. ASTM International (ASTM):

- 1. A126: Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

- 2. A153/A153M: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

3. A536: Standard Specification for Ductile Iron Castings
4. B209/B209M: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

E. American Welding Society (AWS):

1. D1.1/D1.1M: Structural Welding Code – Steel

F. American Water Works Association (AWWA):

1. C606: Grooved and Shouldered Joints

G. Manufacturers' Standardization Society (MSS):

1. SP-67: Butterfly Valves
2. SP-68: High Pressure Butterfly Valves with Offset Design

H. National Fire Protection Association (NFPA):

1. 70: National Electrical Code.
2. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems
3. 90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

I. Underwriters' Laboratories, Inc. (UL):

1. 900: Standard for Safety Air Filter Units

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Delegated Design Submittals: For each device, equipment or appurtenance provide written certification from Professional Engineer licensed in the State of Utah stating that supports systems, anchorage and equipment have been designed according to the requirements of Section 1613 of the building codes of Utah, ASCE/SEI 7, and in accordance with Specification 01 41 20. Submit calculations stamped by a Professional Engineer licensed in the State of Utah for support systems and anchorage for wind, seismic, and all other pertinent loads.
- C. Submit complete layout drawings and lists for metal framing. Submit member sizes, materials, details, connections, and fasteners for studs, joists, lintels, bracing, and runners. Submit calculations for design of lintels and their supports that are signed and stamped by a Civil Engineer registered in the State of Utah.

- D. Operation and Maintenance Data:
 - 1. Operation and maintenance manuals shall be specific to equipment purchased and crossing out of non-applicable items is not acceptable.
 - 2. Comply with requirements of Section 01 78 23.
- 1.04 CODES AND STANDARDS:
 - A. IBC, Chapter 22, Section 2210
 - B. "Specifications for the Design of Cold-Formed Steel Structural Members" by AISI.
 - C. Welding: Structural Welding Code, AWS D1.1.
 - D. Welding Qualifications: Qualify welders and welding procedures in accordance with AWS D1.1. Provide certification that welders employed in the work have been engaged in the qualified welding procedure within the last six months.
- 1.05 SPARE PARTS:
 - A. Comply with the requirements specified in Section 01 61 00.
 - B. Provide spare parts that are identical to and interchangeable with similar parts installed.
 - C. Provide a list of recommended spare parts for the first year of operation and for the first five years of operation, including a price list and location of the nearest facility from which all spare parts can be obtained.
- 1.06 DESIGN:
 - A. Design lintels over openings in walls and their connections and supports for all dead, live, wind, and seismic loads tributary thereto.
 - B. Use design loads prescribed by the IBC. Use the prescribed wind and seismic loads considering the project location.
- 1.07 QUALITY ASSURANCE:
 - A. Comply with the requirements specified in Section 01 43 00.
- 1.08 DELIVERY STORAGE AND HANDLING:
 - A. Comply with the requirements specified in Section 01 66 10.
- 1.09 WARRANTY:
 - A. Comply with the requirements specified in Section 01 78 36.

PART 2 - PRODUCTS

2.01 STUDS, JOISTS, AND RUNNERS

- A. Studs and joists shall be cold-formed galvanized steel channels with section properties and sizes conforming to those indicated in the drawings. Material shall conform to ASTM A653, SS Grade 50.
- B. Runners shall be cold-formed galvanized steel having the same gauge as the studs unless otherwise noted. Material shall conform to ASTM A653, SS Grade 33.
- C. Hot-dipped galvanizing of members shall conform to ASTM A653.
- D. Provide punch-outs in member webs at 24 inches on center and 12 inches from ends.

2.02 LATERAL WALL BRACING:

- A. Provide cold-formed hot-dipped galvanized steel channels 1 1/2 inches deep with flanges not less than 7/16-inch wide. Use hot-dipped galvanized steel clips as recommended by the stud manufacturer for the depth and gauge of studs used.

2.03 CLIPS, CLOSURES, AND STIFFENERS:

- A. Provide cold-formed hot-dipped galvanized steel accessories as recommended by the stud and joist manufacturer to construct the cold-formed member framing system.

2.04 FASTENERS:

- A. Use fasteners or welds of the type and size recommended by the manufacturer unless otherwise noted in the drawings. Do not use powder-actuated fasteners closer than 3 inches from concrete edges or corners. Use self-drilling screws complying with ASTM C1513 or welded connections between metal members.

PART 3 - EXECUTION

3.01 STUD WALLS:

- A. Locate and align floor tracks accurately. Secure to floor with 5/32-inch-diameter power-driven anchors at 24 inches on center unless noted otherwise and not less than 6 inches from ends of each piece of floor track. Install anchors with washers.
- B. Abutting lengths of runner shall each be securely anchored to a common structural element, butt-welded, or spliced.
- C. Align ceiling tracks by plumbing up from floor tracks. Fasten to structure above or to suspended ceiling furring channels with screws at 24 inches on center. Provide bridging when tracks parallel furring channels. Partitions not supported by suspended ceiling shall

be braced at top to floor or roof structure above. Design bracing for a 5-psf lateral load on partitions.

- D. Install metal studs in floor and ceiling tracks or to floor or roof as shown and attach to tracks with screws. Do not use spliced studs. Space studs as shown in drawings. Where not shown or noted, spacing shall be 16 inches on center.
 - E. Horizontally reinforce partitions extending from floor to top with lateral wall bracing channels running through studs at 3-foot on center spacing which are welded or screwed to the studs as recommended by the stud manufacturer.
 - F. Use doubled studs beneath joists and at corners and openings.
 - G. Install reinforcing plates as recommended by the stud manufacturer for the mounting of items on or in partitions, furred walls, or shafts. Firmly and solidly mount items attached to or in gypsum board surfaces.
 - H. Erection technique shall result in plumb and straight walls with no waves or buckles or unevenness at joints. Finished walls shall have a maximum variation of 1/8 inch in 10 feet when checked in any direction with a 10-foot straightedge.
 - I. Do not cut or drill holes through members unless specifically detailed or permitted by the Owner's Representative.
 - J. Do not wire-tie framing members. Use screws or welds.
 - K. Use no splices in studs or runners in braced panels, shear wall panels, or over lintels.
- 3.02 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 50 00
MISCELLANEOUS METAL

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section includes metal fabrications not specifically included in other Sections and required for completion of work as shown on Contract Drawings and in accordance with Contract Documents.
- B. Furnish labor, materials, equipment and incidentals necessary to install the products specified.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B18.5: Round Head Bolts
- B. ASTM International (ASTM):
 - 1. A6: General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling.
 - 2. A36: Standard Specification for Carbon Structural Steel.
 - 3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 4. A108: Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality.
 - 5. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 6. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 7. A193: Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 8. A240: Standard Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels.

9. A276: Standard Specification for Stainless Steel Bars and Shapes.
10. A307: Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
11. A366: Standard Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality.
12. A489: Standard Specification for Carbon Steel Lifting Eyes.
13. A500: Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
14. A501: Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
15. A536: Standard Specification for Ductile Iron Castings. (Applies to Early Work Package 2 only.)
16. A569: Steel, Carbon (0.15 Maximum, Percent) Hot-Rolled Sheet and Strip Commercial Quality.
17. A570: Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
18. A572: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
19. A576: Steel Bars, Carbon, Hot-Wrought, Special Quality.
20. A675: Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties.
21. A786: Rolled Steel Floor Plates.
22. A929: Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
23. A992: Standard Specification for Structural Shapes.
24. B26: Specification for Aluminum-Alloy Sand Castings.
25. B211: Specification for Aluminum-Alloy Bars, Rods, Profiles and Tubes.
26. B209: Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
27. B221: Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.
28. B247: Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings and Rolled Ring Forgings.

29. B308: Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
 30. B429: Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
 31. D1056: Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
 32. F436: Standard Specification for Hardened Steel Washers.
 33. F541: Standard Specification for Alloy Steel Eyebolts.
 34. F593: Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 35. F594: Standard Specification for Stainless Steel Nuts.
 36. F844: Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
 37. F1554: Standard Specification of Anchor Bolts, steel, 36, 55 and 105-ksi Yield Strength.
 38. F2329: Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
 39. F3125: Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- C. American Institute of Steel Construction (AISC):
1. ANSI/AISC 360-5: Specification for Structural Steel Buildings
 2. AISC Manual of Steel Construction, Thirteenth Edition
- D. American Welding Society (AWS):
1. A2.4: Standard Symbols for Welding, Brazing, and Nondestructive Examination
 2. D1.1: Structural Welding Code
 3. D1.2: Structural Welding Code - Aluminum
- E. National Association of Architectural Metal Manufacturers (NAAMM):
1. MBG 531: Metal Bar Grating Manual
 2. MBG 532: Heavy Duty Metal Bar Grating Manual

3. MBG 533: Welding Specifications for Fabrication of Steel, Aluminum and Stainless Bar Grating

F. Aluminum Association:

1. Aluminum Design Manual–Specifications and Guidelines for Aluminum Structures.
 - a. AA M31C22A41
 - (1) M31: Mechanical Finish, Fine Satin
 - (2) C22: Finish, Medium Matte
 - (3) A41: Clear Anodic Coating, Class I

G. National Sanitation Foundation (NSF):

1. 61: Drinking Water System Components – Health Effects

H. Submit the following shop drawings in accordance with Section 01 33 00.

1. Submit shop drawings and product data showing materials of construction and details of installation for all items furnished under this Section. Shop drawings shall show sizes of members, method of assembly, anchorage and connection to other members.
2. Test Reports:
 - a. Submit certified copies of mill test reports on each steel, stainless steel, or aluminum proposed for use showing the physical properties and chemical analysis.
3. Product Data:
 - a. Manufacturer’s catalog sheets on pre-manufactured items.
4. Miscellaneous Submittals:
 - a. Provide International Conference of Building Officials (ICBO) or other similar building code organization recommendations regarding safe allowable design loads for concrete anchors.
5. Stamped by Professional Engineer registered in State where the project is located.

1.03 DESIGN CRITERIA:

- A. Structural Connections: AISC Specification for Structural Steel Buildings. Design connections not fully detailed on the Drawings to resist the loads shown on the Contract Drawings or specified.

- B. Where beam end reactions are not shown, design the connection for one-half the total allowable uniform load in kips for beams laterally supported at the given span, as determined by the tables for allowable loads on beams in the AISC Manual of Steel Construction, in addition to any axial loads identified on the Contract Drawings.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Test and inspect structural assemblies in accordance with Section 01 45 33.
- C. Design connections not detailed on the Drawings under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State of Utah.
- D. Steel:
 - 1. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material, except mill scale that will withstand vigorous wire brushing may remain. Perform no welding when base metal is lower than 0 degrees F.
 - 2. Qualify welding operators in accordance with AWS D1.1. Qualification tests shall be run by a recognized testing laboratory acceptable to the Engineer at Contractor's expense.
- E. Aluminum:
 - 1. Weld with gas metal arc (GMA) or gas tungsten arc (GTA) processes in accordance with AWS.
- F. Adhesive Anchors:
 - 1. Adhesive Anchor Installers shall be trained and certified by manufacturer.
- G. Galvanized Coating:
 - 1. Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 61 00.
- B. Insofar as practical, factory assemble items specified herein. Package, ship and tag unassembled materials in a manner that will protect materials from damage and will facilitate identification and field assembly.
- C. Package stainless steel items in a manner to provide protection from carbon impregnation.

- D. Protect painted coatings and hot-dip galvanized finishes from damage due to metal banding and rough handling. Use padded slings and straps.
- E. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.
- F. Store fabricated items in a dry area, not in direct contact with ground.

1.06 FIELD MEASUREMENTS:

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.
- B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

PART 2 - PRODUCTS

2.01 MISCELLANEOUS METAL SHAPES, CASTINGS, BOLTS AND ACCESSORIES:

A. Structural Steel Shapes:

- | | |
|---------------------------------------|----------------------------|
| 1. W Shapes: | ASTM A992, 50 ksi |
| 2. S, C and MC Shapes: | ASTM A36 |
| 3. L Shapes: | ASTM A36 |
| 4. HSS Square and Rectangular Shapes: | ASTM A500, Grade C, 50 ksi |
| 5. HSS Round Shapes: | ASTM A500, Grade C, 46 ksi |
| 6. Pipe Shapes: | ASTM A53, Grade B, 35 ksi |
| 7. Plates and Bars: | ASTM A36 |
| 8. Steel Sheets: | ASTM A366 |

B. Stainless Steel Shapes:

- | | |
|-------------------------------------|----------------------------|
| 1. Exterior and Submerged Uses: | AISI, Type 316 |
| 2. Industrial Uses: | AISI, Type 316 |
| 3. Interior and Architectural Uses: | AISI, Type 304 |
| 4. For Welding: | AISI, Type 304L, Type 316L |

5. Shapes and Bars ASTM A276
6. Plate, Sheet and Strip ASTM A240
- C. Aluminum Shapes:
 1. Structural Shapes ASTM B308, Alloy 6061-T6
 2. Extruded Pipe ASTM B429, Alloy 6063-T6
 3. Aluminum Sheet and Plate ASTM B209, Alloy 6061-T6
- D. High Strength Bolts for Steel Members ASTM F3125
- C. Steel Washers ASTM F436
- D. Plain Unhardened Steel Washers: ASTM F844
- E. Anchor Bolts: ASTM F1554, Grade 36 standard headed bolts with heavy hex nuts, Grade A washers, hot-dip galvanized, unless otherwise specified.
- F. Stainless Steel Bolts and Nuts: F593 and F594, AISI Type 316
- G. Connection Bolts for Wood Members: ASTM A307, galvanized where specified
- H. Iron Castings: ASTM A48, Class 35
- I. Galvanizing: ASTM A123, Zn w/0.5 percent minimum Ni.
- J. Galvanizing, hardware: ASTM A153, Zn w/0.5 percent minimum Ni.
- 2.02 POST INSTALLED ANCHORS:
 - A. Mechanical Expansion Type Anchors: Anchors shall be qualified per ICC-ES AC193.
 1. Products:
 - a. Hilti Corporation, Kwik-Bolt TZ
 - b. Dewalt, Power Stud SD1+ Stud Anchor
 - c. Simpson Strong Tie, Strong Bolt
 2. General:
 - a. Use Zinc or chromate-plated carbon steel where totally embedded, in interior locations with controlled humidity and other protected locations, unless otherwise specified on Contract Drawings.

- b. Use stainless steel in other locations or when attaching aluminum and stainless steel.
 - c. Do not use expansion anchors in submerged and dynamic load applications.

B. Drop-In Anchors: Anchors shall be qualified per ICC-ES AC01.

1. Products:

- a. Hilti Corporation, HDI Drop-In Anchor
- b. Dewalt Fasteners, Steel Drop-In

2. General:

- a. Use Zinc or chromate-plated carbon steel in interior locations with controlled humidity and other protected locations, unless otherwise specified on Contract Drawings.
- b. Use stainless steel in other locations or when attaching aluminum and stainless steel.
- c. Do not use drop-in anchors in corrosive or humid areas or when subjected to dynamic loads.

C. Adhesive Anchors:

1. Products:

- a. Hilti Corporation, HIT-HY 200
- b. Dewalt Fasteners, PE1000+ Epoxy Adhesive Anchoring System
- c. Simpson Strong Tie, SET-XP Epoxy-Tie or Acrylic-Tie

2. General:

- a. Adhesive anchors shall be hot-dipped galvanized.
- b. Use stainless steel in other locations or when attaching aluminum and stainless steel. Anchors in submerged locations shall be stainless steel Type 316.

2.03 ANCHOR CHANNEL INSERTS:

- A. Make anchor channels from channel profiles with “T” anchors shop welded to back of channels. Furnish anchor channels with head bolts, channels, nuts for a complete installation. Material shall be Stainless Steel Type 304.

2.04 WEDGE INSERTS:

A. Manufacturers:

1. Gateway Building Products
2. Richmond Screw Anchor Company

B. General:

1. Malleable iron casting, 3/4-inch minimum size with minimum combined working load capacity of 1,300 pounds in shear and 1,000 pounds in tension.
2. Stainless Steel bolts and hardware.

2.05 EYE BOLTS:

- A. Provide eyebolts of the welded-eye or forged type, carbon steel hot-dipped galvanized steel per ASTM F2329.
- B. Provide threaded carbon steel lifting eyes that comply with ASTM A489, Type 1, Style B.
- C. Provide threaded alloy steel eyebolts that comply with ASTM F541 and ASME B18.5, Type 1, long length.

2.06 GRATING SUPPORT ANGLES AND FRAMING:

- A. Provide stainless steel support angles embedded in concrete. Angles shall be 1/4-inch thick, inside depth of support angle shall equal depth of bearing bar, inside length of support angle leg shall equal depth of grating. Provide 1 inch by 1/4-inch by 8 inches long bent anchor bars or 3/8-inch diameter by 6 inch headed anchor studs welded to backs of angles at 18 inches on center. (Applies to Early Work Package 2 only.)
- B. Provide stainless steel support angles embedded in concrete. Angles shall be equal depth of bearing bar, inside length of support angle leg shall equal depth of grating, but not less than 1-3/4 inch. Provide long bent anchor bars or headed anchor studs welded to backs of angles as indicated on the Contract Drawings.
- C. For fiberglass reinforced plastic grating provide supports and framing in accordance with Section 06 60 10.

2.07 METAL FRAMES:

- A. Provide door, hatch, and grille frames, and other frames fabricated from structural shapes, as indicated on the Contract Drawings.
- B. Fabricate frames from rolled steel sections or rolled steel sections and steel plates. Select sections for trueness of web and flange. Straighten members so finished frames are uniform, square, and true throughout length and depth of assembled units.

- C. Connect built-up members of frames by plug welding. Miter or cope and join members with continuous welding beads. Provide temporary spreader bars to prevent springing frames out of shape prior to and during erection.

2.08 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.
- B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
- C. Fabricate units from slotted channel framing where indicated.
- D. Furnish inserts for units installed after concrete is placed.
- E. Galvanize miscellaneous framing and supports where indicated.
- F. Prime miscellaneous framing and supports with primer specified in Section 099600 "High-Performance Coatings" where indicated.

2.09 ABRASIVE METAL NOSINGS

- A. Cast aluminum, with an integral-abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - 1. Cross-hatched nosings, 4 inches (100 mm) wide, with 1/4-inch- (6-mm-) thick 1-inch (25-mm) lip, for casting into concrete.
- B. Cast stainless steel, Type 316, with checkered plate, as-cast mill finish. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - 1. Cross-hatched nosings, 2 inches (50 mm) wide, with 1/4-inch- (6-mm-) thick 1-inch (25-mm) lip, for casting into concrete.
- C. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
- D. Drill for mechanical anchors and countersink. Locate holes not more than 4 inches (100 mm) from ends and not more than 12 inches (300 mm) o.c., evenly spaced between ends, unless otherwise indicated. Provide closer spacing if recommended by manufacturer.
 - 1. Provide two rows of holes for units more than 5 inches (125 mm) wide, with two holes aligned at ends and intermediate holes staggered.
- E. Apply bituminous paint to concealed surfaces of cast-metal units.

2.10 STRAP ANCHORS AND STUD ANCHORS:

- A. Provide anchors for frames, curbs, sills, and other metal fabrications anchored into concrete or masonry. Fabricate anchors from strap iron, bent to shape, or of weldable studs, welded to backs of members. Where size and spacing not noted, provide 1 inch by 1/4-inch strap anchors or 3/4-inch diameter studs for concrete and 1-1/2 inch by 1/8-inch strap anchors for masonry. Space masonry anchors to fit jointing of adjacent masonry work at 4 feet on center. Space concrete anchors at 3 feet on center.
- B. Where anchors and plates or clips are to be built in for attachment of later Work, provide bolts in plates or clips, welded to back, with threaded ends extended.
- C. For attaching Work to concrete where anchors or inserts cannot be built in, provide concrete anchors or machine bolts and screws.

2.11 NEOPRENE GASKET:

- A. Provide soft, closed-cell neoprene gasket material suitable for exposure to sewage and sewage gases conforming to ASTM D1056, Type 2, Class C, and Grade 1.
- B. Unless otherwise shown on Contract Drawings, provide neoprene gaskets with a minimum thickness of 1/4-inch.
- C. Furnish neoprene gaskets without skin coat.

2.12 MAINTENANCE HOLE STEPS:

- A. Manufacturers:
 - 1. Aluminum:
 - a. Neenah Foundry Inc., Type R-1982-W
 - b. Campbell.
 - 2. Cast Iron:
 - a. Neenah Foundry Inc., Type R-1980-J
 - b. Campbell, Type Pattern 2581
 - 3. Plastic Coated Steel:
 - a. 3/8-inch diameter steel reinforcing rod with molded plastic cover.

B. General:

1. Provide aluminum for wet wells, cast-in-place maintenance holes, and where shown, except noted below for precast maintenance holes. Separate dissimilar metals. Provide epoxy coating for aluminum to be in contact with concrete.
2. Provide aluminum for wet wells, cast-in-place maintenance holes, and where shown, except noted below for precast maintenance holes. Separate dissimilar metals.
3. Provide cast iron or plastic coated steel for precast maintenance holes only.

2.13 MAINTENANCE HOLE COVERS AND FRAMES:

A. Manufacturers:

1. Neenah Foundry Inc.
2. Campbell

B. General:

1. Assemblies shall be of dimension and type as shown on Contract Drawings.

2.14 STEEL BOLLARDS:

- A. Galvanized steel pipe bollards shall be fabricated to dimensions and details shown in Contract Drawings. Fabricated bollards from 6 inch nominal outside diameter Schedule 80 steel pipe.
- B. Fabricate bollards with 3/8-inch- (9.5-mm-) thick, steel baseplates for bolting to concrete slab. Drill baseplates at all four corners for 3/4-inch (19-mm) anchor bolts.
- C. Where bollards are to be anchored to sloping concrete slabs, angle baseplates for plumb alignment of bollards.
- D. Finish: Where indicated on Drawings:
 1. Prime and field paint, color as indicated on Drawings. Refer to Section 099600 "High-Performance Coatings."
 - a. Applied Markings: Adhesive, white reflective markings, applied to painted bollards.
 2. Provide HDPE bollard cover with reflective markings, colors as indicated on Drawings.

2.15 FABRICATION:

A. Connections and Workmanship:

1. Fabricate details and connection assemblies in accordance with Contract Drawings and Specifications, with projecting corners clipped and filler pieces welded flush.
2. Fit work together in fabrication shop and deliver complete or in parts, ready to be set in-place or assembled in field.
3. Provide work true to detail; with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture free from defects impairing strength or durability.
4. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, as required for fabrication and erection.
5. Provide castings of uniform quality, free from blowholes, porosity, hard spots, shrinkage distortion; smooth and well cleaned by shot blasting.
6. Welding:
 - a. Provide rigid and continuous welds or spot welded as specified and as shown on Contract Drawing. Dress the face of welds flush and smooth. Close fit exposed joints and locate where least conspicuous.
 - b. Weld aluminum work on the unexposed side when possible in order to prevent pitting or discoloration.
 - c. Weld aluminum in compliance with the latest edition of AWS D1.2. Support and clamp component parts of built-up members in proper position for welding.
 - d. Weld shop connections and bolt or field weld connections, unless otherwise specified.
 - e. Grind exposed edges of welds to 1/8-inch minimum radius. Grind burrs, jagged edges, and surface defects smooth.
 - f. Prepare welds and adjacent areas so there is:
 - (1) No undercutting or reverse ridges on weld bead.
 - (2) No weld spatter on or adjacent to weld or other area to be painted or coated.
 - (3) No sharp peaks or ridges along weld bead.
7. Bolting:
 - a. Use bolts of lengths required so bolts do not project more than 1/4-inch beyond face of nut. Do not use washers unless specified. Provide hexagonal head bolts with hexagonal nuts.

- b. Provide holes required for connection of adjacent or adjoining work wherever noted on Drawings. Locate holes for bolting equipment to supports to tolerance of +/- 1/16-inch of dimensions indicated.
- B. Galvanizing:
 - 1. Galvanize after fabrication by hot-dipped process conforming with ASTM A123.
 - 2. Ship and handle in manner to avoid damage to zinc coating.
- C. Painting of aluminum in contact with concrete:
 - 1. Coat areas of aluminum fabrications in contact with concrete with high solids epoxy or phenolic epoxy having a minimum volume solids of 80 percent (ASTM D2697). Maximum thickness of an individual coating shall not exceed the manufacturer's recommendation.
 - 2. Manufacturers:
 - a. PPG, Amerlock 400 or 400VOC
 - b. PPG, PITT-GUARD® Direct-to-Rust Epoxy Mastic Coating 97-145 series
 - c. Tnemec, Chembuild Series 135

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Upon receipt of material at job site, inspect all materials for shipping damage. Replace damaged items at no cost to Owner.
- B. Examine supports for size, layout and alignment.
- C. Correct defects considered detrimental to proper installation.

3.02 INSTALLATION:

- A. Provide items such as bolts, shims, blocks, nuts, washers, and wedging pieces to complete installation.
- B. Erect to lines and levels, plumb and true, and in correct relation to adjoining Work. Secure parts using concealed connections when practicable.
- C. Plumb and true vertical members to tolerance of +/- 1/8 inch in 10 feet. Level horizontal members to tolerance of +/- 1/8 inch in 10 feet.

- D. Use steel bolts to connect structural steel members. Use stainless steel bolts to connect structural aluminum members.
 - E. Anchor Bolts and Concrete Anchors:
 - 1. Preset anchor bolts using templates. Do not use concrete anchors in place of anchor bolts.
 - 2. After anchor bolts are embedded, protect projecting threads by applying grease and having the nuts installed until the time of installation of equipment or metalwork.
 - 3. Do not install concrete anchors until concrete has reached specified minimum compressive strength.
 - 4. Install concrete anchors in accordance with anchor manufacturer recommendation. Embedment depth of anchor shall be as recommended by the anchor manufacturer, but not less than as shown on Contract Drawings.
 - 5. Locate concrete anchors to clear reinforcing bars in concrete.
 - F. Weld headed anchor studs in accordance with manufacturer's recommendations.
 - G. Do not place new holes or enlarge unfair holes by use of cutting torch.
 - H. Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.
 - 1. Anchor supports for overhead doors securely to, and rigidly brace from, building structure.
 - I. Bollards:
 - 1. Anchor bollards, where indicated, with anchor bolts. Provide four bolts at each bollard unless otherwise indicated. Embed anchor bolts at least 4 inches (100 mm) in concrete.
 - 2. Anchor bollards in place with concrete footings where indicated. Center and align bollards in holes 3 inches (75 mm) above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.
 - 3. Fill bollards solidly with concrete, mounding top surface to shed water.
- 3.03 PAINTING, REPAIR, AND PROTECTION:
- A. Prepare surface of aluminum in contact with concrete.

1. Prepare aluminum surface by solvent or steam cleaning per SSPC SP-1; do not use alkali cleaning. Then dust blast.
 2. Paint aluminum in contact with concrete with three or more coats of high solids epoxy or phenolic epoxy. Under no circumstances shall aluminum contact dissimilar metal.
- B. Under no circumstances shall aluminum contact dissimilar metal.
- C. Between aluminum grating, aluminum stair treads, or aluminum handrail brackets and steel supports, insert 1/4-inch thick neoprene isolator pads, 85 +/- 5 Shore A durometer, sized for full width and length of bracket or support.
- D. Apply an anti-seize compound on all stainless steel fasteners to prevent galling.
- E. Field Repair of Damaged Galvanized Coatings:
1. Clean and repair Zinc coating that has been burned by welding, abraded, or otherwise damaged after installation. Clean damage area by wire brushing and removing all traces of welding flux and loose or cracked zinc coating.
 2. Coat surfaces using zinc-rich paint.
- F. Field repair of damaged primer.
1. Touch up abrasions in the shop primer immediately after erection. Paint areas left unprimed for welding with primer after welding.
- 3.04 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 51 10

STEEL AND STAINLESS STEEL LADDERS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide ladders as indicated and in compliance with Contract Documents.
 - 1. Section Includes:
 - a. Vertical steel and stainless steel ladders
 - 2. Related Requirements:
 - a. Section 11 24 29 "Facility Fall Protection" for ladder fall protection systems.

1.02 PERFORMANCE/DESIGN CRITERIA:

- A. Ladders shall conform to OSHA and IBC requirements.
- B. Vertical ladders shall be designed to withstand a minimum of two loads of 250 pounds (1.1 kN) each, concentrated between any two consecutive attachments. The number and spacing of additional loads shall be in accordance with the anticipated usage of the ladder. Individual steps or rungs shall be designed to support a load of 250 pounds (1.1 kN) applied at any point.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Shop drawings showing clearly the location, size and details of all members
 - 2. Indicate materials, dimensions, connection attachments, anchorage, size and type of fasteners, holes, finishes, and accessories for ladders.
 - 3. Reference materials of construction by ASTM designation and grade.
 - 4. Indicate welds including length and size of all shop and field welds by symbols conforming to AWS standards.
 - 5. Letter certifying that ladders are designed and detailed to meet the requirements of standards, building codes, specifications and design criteria herein described.
- B. Product Data:
 - 1. Manufacturer's catalog sheets on pre-manufactured items.

2. Manufacturer's specifications, load tables, anchor details, and installation details.

C. Certificates:

1. Welders' Certificates: Certifying welders employed on the Work, verifying AWS qualification within the previous 12 months.
2. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.
3. Certificate stating that the zinc coating conforms to the ASTM specified requirements.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Obtain field measurements and elevations prior to preparation of shop drawings and fabrication.
- C. Welding Qualification and Certification:
 1. Furnish written welding procedure for all welds in conformance with AWS Structural Welding Code.
 2. Use welders, tackers and welding operators certified by test to perform type of work required in conformance with AWS Structural Welding Code. Maintain current test records certified by an independent testing laboratory.
 3. Maintain duplicate qualification and certification records at the job site readily available for examination.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10
- B. Identify and match-mark materials, items and fabrications, for installation and field assembly.
- C. Deliver items to jobsite as complete units, wherever practicable, ready for installation or erection, with anchors, hangers, fasteners and miscellaneous metal items required for installation.
- D. Carefully handle and store materials, protected from weather, corrosion and other damage.
- E. Store off the ground on suitable supports.
- F. Accept material on site. Inspect for damage.

- G. Do not incorporate damaged materials in the work.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Steel materials and welding electrodes per Section 05 12 00.
- B. Stainless Steel:
1. AISI Type 304 unless otherwise indicated or specified. AISI Type (or Grade) 304L for welding.
 2. AISI Type 316 unless otherwise indicated or specified. AISI Type (or Grade) 316L for welding.
 3. Shapes and Bars: ASTM A276.
 4. Sheet, strip, plate and flat bar: ASTM A167.
 5. Pipe: ASTM A312.
 6. Tubing: ASTM A269.
- C. Welding Electrodes:
1. Welding electrodes for structural steel shall conform to AWS A5.5. Use electrodes in the E-70 series.
 2. Welding electrodes for stainless steel shall conform to AWS A 5.4. Use electrodes as follows:

Table 05 51 10-1	
Stainless Steel Material	Welding Electrode Material
Type 304	E308
Type 304L	E347
Type 316	E316
Type 316L	E318

2.02 FABRICATION:

- A. General:
1. Fabricate true to shape, size and tolerances as indicated and specified.
 2. Straighten work bent by shearing or punching.

3. Dress exposed edges and ends of metal smooth, with no sharp edges and with corners slightly rounded.
4. Provide sufficient quantity and size of anchors for the proper fastening of the work.
5. Fabricate details and connection assemblies in accordance with drawings, with projecting corners clipped and filler pieces welded flush.
6. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, for fabrication and erection.
7. Use connections of type and design required by forces to be resisted, and to provide secure fastening.
8. Fit work together in fabrication shop and deliver complete, or in parts, ready to be set in place.

B. Welding:

1. Grind exposed edges of welds to a 1/8 inch (3.2 mm) minimum radius. Grind burrs, jagged edges and surface defects smooth.
2. Prepare welds and adjacent areas such that there is no undercutting or reverse ridges on the weld bead and no sharp peaks or ridges along the weld bead.
3. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.

C. Bolting:

1. Provide galvanized stud bolts, nuts and washers for fastening galvanized steel material.
2. Provide holes required for the connection of adjacent or adjoining work wherever noted on drawings. Locate holes for bolting to supports to a tolerance of 1/16-inch (2 mm) of exact dimensions indicated.

2.03 VERTICAL LADDERS:

- A. Fabricate ladders as shown in the drawings. Ladders shall be welded steel construction and galvanized after fabrication or Type 304/316 stainless steel, as indicated in the contract drawings.
- B. Minimum diameter of rungs shall be 3/4-inch (20 mm). The distance between rungs, cleats, and steps shall not exceed 12 inches (300 mm) and shall be uniform throughout the length of the ladder.
- C. The minimum clear length of rungs or cleats shall be 16 inches (400 mm).

- D. Coat rungs with coarse grain nonskid epoxy coating No. 6901T44 as supplied by McMaster-Carr Supply Company or acceptable equivalent product. Color of coating shall be gray. Apply nonskid coating per manufacturer's recommendations.

2.04 SECURITY COVERS FOR LADDERS:

- A. Provide 6-foot (1,830 mm) high security covers at bottom of ladders. Equip covers with hinges on one side and locking clasp on the other side. Covers shall be 14-gauge galvanized steel or 14-gauge stainless steel, to match ladder material, as manufactured by Carbis Inc., Core Terminal Products, or acceptable equivalent product.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Set and secure in place as indicated. Where bolted connections are used, draw together and draw nuts tightly. Use bolts of lengths required so that they do not project more than 1/4-inch (6 mm) beyond face of nut. Do not use washers unless specified. Provide hexagonal head bolts with hexagonal nuts.
- B. Locate anchors and anchor bolts and build into connecting work.
- C. Install ladders in accordance with shop drawings.

3.02 LADDERS:

- A. Anchor uprights to wall with angles or bent plates welded to uprights and anchored to wall. Grind welds smooth where required. Provide assemblies with no sharp or rough surface.
- B. Secure interior ladders to floor slabs with floor flanges.
- C. Provide fall prevention system as indicated.
- D. Provide angles, struts, rod hangers, closure plates, and brackets indicated.

3.03 REPAIR OF GALVANIZED SURFACES:

- A. Repair or replace metal with damaged galvanized surfaces at no additional cost to the Owner. Repair galvanized surfaces per Section 09 96 00.

3.04 PAINTING:

- A. Painting and coating of steel ladders furnished and applied as specified in Section 09 96 00.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 51 19

METAL GRATING STAIRS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Aluminum grating stairs.
2. Galvanized steel grating stairs.
3. Railings and guards.

B. Related Requirements:

1. Section 05 53 00 "Metal Grating, Cover Plates, and Access Hatches" for metal gratings used in cover plate applications.
2. Section 06 60 10 "Fiberglass Reinforced Products and Fabrications" for FRP gratings, stairs, and railings.

1.02 COORDINATION

A. Coordinate installation of anchorages for metal stairs, railings, and guards.

1. Furnish setting drawings, templates, and directions for installing anchorages, including anchor bolts, blocking for attachment of wall-mounted handrails, and items with integral anchors, that are to be embedded in concrete or masonry.
2. Deliver such items to Project site in time for installation.

B. Schedule installation of railings and guards so wall attachments are made only to completed walls.

1. Do not support railings and guards temporarily by any means that do not satisfy structural performance requirements.

1.03 ACTION SUBMITTALS

A. Product Data: For metal grating stairs and the following:

1. Gratings.

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachment to other work.
 2. Indicate sizes of metal sections, thickness of metals, profiles, holes, and field joints.
 3. Include plan at each level.
 4. Indicate locations of anchors, weld plates, and blocking for attachment of wall-mounted handrails.
- C. Delegated Design Submittal: For stairs, railings, and guards, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer's experience with providing delegated design engineering services of the kind indicated, including documentation that engineer is licensed in the State in which Project is located.
- B. Welding certificates.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 2. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification.
1. Keep stair members off ground and spaced by using pallets, dunnage, or other supports and spacers.
 2. Protect stair members and packaged materials from corrosion and deterioration.
 3. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures.
 - a. Repair or replace damaged materials or structures as directed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 to design stairs, railings, and guards, including attachment to building construction.
- B. Structural Performance of Stairs: Metal stairs withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Uniform Load: 100 lbf/sq. ft. (4.79 kN/sq. m).
 - 2. Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 - 3. Uniform and concentrated loads need not be assumed to act concurrently.
 - 4. Stair Framing: Capable of withstanding stresses resulting from railing and guard loads in addition to loads specified above.
 - 5. Limit deflection of treads, platforms, and framing members to $L/360$.
- C. Structural Performance of Railings and Guards: Railings and guards, including attachment to building construction, withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
 - 3. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- D. Seismic Performance of Stairs: Metal stairs withstand the effects of earthquake motions determined according to ASCE/SEI 7 and in accordance with Section 01 42 00.

1. Component Importance Factor: 1.0.

2.02 METALS

- A. Metal Surfaces: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Provide galvanized finish for all steel.
- C. Steel Plates, Shapes, and Bars:
 1. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
 2. Rolled-Steel Floor Plate: ASTM A786/A786M, rolled from plate complying with ASTM A36/A36M or ASTM A283/A283M, Grade C or D.
 3. Steel Bars for Grating Treads: ASTM A36/A36M or steel strip, ASTM A1011/A1011M or ASTM A1018/A1018M.
 4. Steel Wire Rod for Grating Crossbars: ASTM A510/A510M.
- D. Steel Tubing for Railings and Guards: ASTM A500/A500M (cold formed) or ASTM A513/A513M.
- E. Steel Pipe for Railings and Guards: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
- F. Aluminum Plates, Shapes, and Bars:
 1. Plate: Alloy 6061-T6, Mill Finish, Heat Treatable.
 2. Structural Shapes: Alloy 6061-T6, ASTM B 308
 3. Sheet Aluminum: ASTM B209 (ASTM B209M), Alloy 5052, H32 or H22 Temper.
 4. Round Pipe: Alloy 6061-T6, ASTM B429
 5. Square Tubing: Alloy 6063-T52, Extruded
 6. Rectangular Tubing: Alloy 6063-T52, Extruded
 7. Aluminum- Alloy Bars: ASTM B211 (ASTM B211M), Alloy 6061-T6
- G. Aluminum Bars for Grating Treads: ASTM B221 (ASTM B221M) extruded aluminum, alloys as follows:
 1. 6061-T6 or 6063-T6, for bearing bars of gratings and shapes.

2. 6061-T1, for grating crossbars.

H. Aluminum for Railings and Guards:

1. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
2. Extruded Bars and Tubing: ASTM B221 (ASTM B221M), Alloy 6063-T5/T52.
3. Extruded Structural Pipe and Round Tubing: ASTM B429/B429M, Alloy 6063-T6.
 - a. Provide Schedule 80 pipe unless otherwise indicated.
4. Drawn Seamless Tubing: ASTM B210/B210M, Alloy 6063-T832.
5. Plate and Sheet: ASTM B209 (ASTM B209M), Alloy 6061-T6.
6. Die and Hand Forgings: ASTM B247 (ASTM B247M), Alloy 6061-T6.
7. Castings: ASTM B26/B26M, Alloy A356.0-T6.

2.03 FASTENERS

- A. General: Provide Type 316 stainless steel fasteners.
 1. Select fasteners for type, grade, and class required.
- B. Fasteners for Anchoring Railings and Guards to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings and guards to other types of construction indicated and capable of withstanding design loads.

2.04 MISCELLANEOUS MATERIALS

- A. Welding Electrodes: Comply with AWS requirements.
- B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with ASTM A780/A780M and compatible with paints specified to be used over it.

2.05 FABRICATION, GENERAL

- A. Provide complete stair assemblies, including metal framing, hangers, railings, guards, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
 1. Join components by welding unless otherwise indicated.
 2. Use connections that maintain structural value of joined pieces.

- B. B. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Fit and shop assemble stair in the largest practical sections for delivery to the job site.
 - 1. Disassemble units only as necessary for shipping and handling limitations.
 - 2. Clearly mark units for reassembly and coordinated installation.
- F. Miter the stringers at changes in direction with joints tightly fitted and secured by continuous welds and grind with #3 NOMMA Finish. Make exposed joints butt tight. Ease exposed edges to a small uniform radius.
- G. Close and fit the ends of stringers at the floor or landing to the floor surface. On the landings and platforms where they are part of the stair framing, carry the wall stringers around and above the finished level of the platform to form a base of the height as shown.
- H. Provide standard prefabricated aluminum grating treads and aluminum nosings with extruded re-enforced profile with non-slip ribs.
 - 1. Mechanically fasten grating treads with aluminum bearing angle to stringers.
 - 2. Grating bearing bars shall be spaced 1-3/16-inches on center and cross bars shall be spaced at 4-inches on center. Cross bars shall be flush at top with bearing bars
 - 3. All Grating edges shall be banded.
 - 4. Unless noted other, all grating at treads and landings will not be welded to supports, provided saddle clips as required for attachment. Limit weight of each section to no more that 50-pounds.
 - 5. Provide aluminum riser plates welded to grating tread, unless drawings indicate other.
- I. Fabricate railings and guards to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of member, post spacings, wall bracket spacing, and anchorage, but not less than that needed to withstand indicated loads.

2.06 FINISHES

- A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- C. Aluminum Mill Finish: AA-M12, nonspecular as fabricated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify elevations of floors, bearing surfaces and locations of bearing plates, and other embedments for compliance with requirements.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF METAL STAIRS

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction.
 - 1. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.
- C. Install metal stair in accordance with the manufacture's recommendations and approved shop drawings.
- D. Install components plumb and level, accurately fitted, free from distortion or defects.
- E. Securely bolt or anchors, plates, angles, hangers, and struts required for connecting stairs to structure.
- F. Provide welded field joints where specifically indicated or shop drawings. Perform field welding in accordance with the appropriate AWS Specification.

- G. Obtain approval prior to site cutting or creating adjustments not scheduled.
- H. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.
- I. Fit exposed connections accurately together to form hairline joints.
 - 1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

END OF SECTION

SECTION 05 52 13

PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Aluminum railings.
2. Stainless Steel railings.

B. Related Requirements:

1. Section 05 51 19 "Metal Grating Stairs" for railings associated with metal grating stairs.
2. Section 07 72 00 "Roof Accessories" for railings associated with roof hatches.

1.02 COORDINATION

- ###### A.
- Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.03 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's product lines of mechanically connected railings.
2. Fasteners.
3. Post-installed anchors.
4. Handrail brackets.
5. Bituminous paint.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Delegated Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For delegated design professional engineer.
- B. Welding certificates.
- C. Mill Certificates: Signed by manufacturers of stainless steel products, certifying that products furnished comply with requirements.
- D. Product Test Reports: For tests on railings performed by a qualified testing agency, in accordance with ASTM E894 and ASTM E935.
- E. Research Reports: For post-installed anchors, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.05 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 2. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.07 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 to design railings, including attachment to building construction.
- B. B. Structural Performance: Railings, including attachment to building construction, withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.

- b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
- 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- 2.02 METALS, GENERAL
 - A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
 - B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.
- 2.03 ALUMINUM RAILINGS
 - A. Source Limitations: Obtain each type of railing from single source from single manufacturer.
 - B. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
 - C. Extruded Bars and Tubing: ASTM B221 (ASTM B221M), Alloy 6063-T5/T52.
 - D. Extruded Structural Pipe and Round Tubing: ASTM B429/B429M, Alloy 6063-T6.
 - 1. Provide Schedule 80 pipe unless otherwise indicated.
 - E. Drawn Seamless Tubing: ASTM B210/B210M, Alloy 6063-T832.
 - F. Plate and Sheet: ASTM B209 (ASTM B209M), Alloy 6061-T6.
 - G. Die and Hand Forgings: ASTM B247 (ASTM B247M), Alloy 6061-T6.
 - H. Castings: ASTM B26/B26M, Alloy A356.0-T6.

2.04 STAINLESS STEEL RAILINGS

- A. Source Limitations: Obtain each type of railing from single source from single manufacturer.
- B. Tubing: ASTM A554, Grade MT 316L.
- C. Pipe: ASTM A312/A312M, Grade TP 316L.
- D. Castings: ASTM A743/A743M, Grade CF 8M or CF 3M.
- E. Plate and Sheet: ASTM A240/A240M or ASTM A666, Type 316L.

2.05 FASTENERS

- A. Fastener Materials:
 - 1. Aluminum Railing Components: Type 316 stainless steel fasteners.
 - 2. Stainless Steel Railing Components: Type 316 stainless steel fasteners.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction and capable of withstanding design loads.
- C. Fasteners for Interconnecting Railing Components:
 - 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.
- D. Post-Installed Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193.
 - 1. Alloy Group 1 (A1) stainless steel bolts, ASTM F593, and nuts, ASTM F594.

2.06 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.
 - 1. For aluminum and stainless steel railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- B. Bituminous Paint: Cold-applied asphalt emulsion, complying with ASTM D1187/D1187M.

2.07 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations.
 - 1. Clearly mark units for reassembly and coordinated installation.
 - 2. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that are exposed to weather in a manner that excludes water.
 - 1. Provide weep holes where water may accumulate.
 - 2. Locate weep holes in inconspicuous locations.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with welded connections unless otherwise indicated.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove flux immediately.
 - 4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish #2 welds; good appearance, completely sanded joint, some undercutting and pinholes okay.
- I. Gates: Form gates from metal tube of same material, size, and shape as top rails, with infill to match guards. Provide with cam-type, self-closing hinges for fastening to wall and

overlapping stop with rubber bumper to prevent gate from opening in direction opposite egress.

- J. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
- K. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
 - 1. Fabricate splice joints for field connection, using an epoxy structural adhesive, if this is manufacturer's standard splicing method.
- L. Bend members in jigs to produce uniform curvature for each configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- M. Close exposed ends of hollow railing members with prefabricated cap and end fittings of same metal and finish as railings.
- N. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- O. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
- P. Provide anchorage devices for connecting railings to concrete or masonry work.
 - 1. Fabricate anchorage devices capable of withstanding loads imposed by railings.
 - 2. Coordinate anchorage devices with supporting structure.

2.08 ALUMINUM FINISHES

- A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Mill Finish: AA-M12, nonspecular as fabricated.

2.09 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run grain with long dimension of each piece.
 2. When polishing is completed, passivate and rinse surfaces.
 3. Remove embedded foreign matter and leave surfaces chemically clean.
- C. Stainless Steel Pipe and Tubing Finishes:
1. 180-Grit Polished Finish: Uniform, directionally textured finish.
- D. Stainless Steel Sheet and Plate Finishes:
1. Directional Satin Finish: ASTM A480/A480, No. 4.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements are clearly marked for Installer. Locate reinforcements and mark locations if not already done.

3.02 INSTALLATION, GENERAL

- A. Perform cutting, drilling, and fitting required for installing railings.
1. Fit exposed connections together to form tight, hairline joints.
 2. Install railings level, plumb, square, true to line; without distortion, warp, or rack.
 3. Set railings accurately in location, alignment, and elevation; measured from established lines and levels.
 4. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 5. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 6. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
- B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

- C. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.03 RAILING CONNECTIONS

- A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws, using plastic cement filler colored to match finish of railings.
- B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article, whether welding is performed in the shop or in the field.
- C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve, extending 2 inches (50 mm) beyond joint on either side; fasten internal sleeve securely to one side; and locate joint within 6 inches (150 mm) of post.

3.04 ANCHORING POSTS

- A. Anchor posts to substrate surfaces with flanges, angle type, or floor type, as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For aluminum railings, attach posts as indicated, using fittings designed and engineered for this purpose.
 - 2. For stainless steel railings, weld flanges to post and bolt to supporting surfaces.

3.05 ATTACHING RAILINGS

- A. Anchor railing ends to concrete and masonry with flanges connected to railing ends and anchored to wall construction with anchors and bolts.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends.
- C. Install railing gates level, plumb, and secure for full opening without interference.
 - 1. Attach hardware using tamper-resistant or concealed means.
 - 2. Adjust hardware for smooth operation.

3.06 CLEANING

- A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.07 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION

SECTION 05 53 00

METAL GRATING, COVER PLATES, AND ACCESS HATCHES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide metal grating, cover plates and access hatches as indicated and in compliance with Contract Documents.
- B. This section includes:
 - 1. Aluminum Bar Grating
 - 2. Steel Grating
 - 3. Aluminum Cover Plates
 - 4. Floor Access Hatches
- C. Furnish all labor, materials, equipment and incidentals necessary to install the products specified.
- D. Related Requirements:
 - 1. Section 05 51 10 "Steel and Stainless Steel Ladders" for ladders including those used at floor access hatches.
 - 2. Section 05 51 19 "Metal Grating Stairs" for aluminum and steel grating stair assemblies.
 - 3. Section 05 52 13 "Pipe and Tube Railings" for safety railings used at floor access hatches.
 - 4. Section 07 72 00 "Roof Accessories" for roof hatches.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. A6: General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling.
 - 2. A36: Standard Specification for Carbon Structural Steel.
 - 3. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

4. A240: Standard Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels.
5. A307: Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
6. A325: Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
7. A569: Steel, Carbon (0.15 Maximum, Percent) Hot-Rolled Sheet and Strip Commercial Quality.
8. A570: Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
9. A575: Steel Bars, Carbon, Merchant Quality, M-Grades
10. A576: Steel Bars, Carbon, Hot-Wrought, Special Quality.
11. A675: Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties.
12. A786: Rolled Steel Floor Plates.
13. A1554: Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength
14. B26: Specification for Aluminum-Alloy Sand Castings.
15. B209: Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221: Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.
17. B247: Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings and Rolled Ring Forgings.
18. F593: Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
19. F594: Standard Specification for Stainless Steel Nuts.

B. American Welding Society (AWS):

1. D1.1: Structural Welding Code.
2. D1.2: Structural Welding Code - Aluminum.

C. National Association of Architectural Metal Manufacturers (NAAMM):

1. MBG 533: Welding Specifications for Fabrication of Steel, Aluminum and Stainless Bar Grating.

D. Aluminum Association:

1. Aluminum Association Designation System for Aluminum Finishes
2. AAMA 607.1: Voluntary Guide Specification and Inspection Methods for Clear Anodic Finishes for Architectural Aluminum

1.03 DESIGN CRITERIA:

A. Grating and Cover Plates:

1. Provide grating and cover plates of minimum depth shown on contract drawings, not exceeding manufacturer's maximum recommended span, and meeting the following load and deflection criteria.
 - a. 100 psf uniform live load or 300 pounds concentrated live load, whichever produces maximum stress
 - b. $L/360$ maximum deflection under uniform live load of 100 psf

B. 12,000 psi maximum flexural stress

C. Interior hatches for the Clearwell shall be "shoe-box" type designed to handle a live load of 625 psf and shall meet the requirements of the Utah Administrative Code Section R309-545-14.

1.04 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Detail shop drawings indicating:
 - a. Dimensions.
 - b. Sectional assembly.
 - c. Location and identification mark.
 - d. Connections and fastening methods.
 - e. Size and location of supporting frames required.
 - f. Materials of construction.
 - g. Installation instructions.
2. Catalog data and design tables showing limits for span length and deflection under load.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Obtain field measurements prior to preparation of shop drawings and fabrication.
- C. Steel:
 - 1. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications. Prepare surfaces to be welded according to requirements of AWS D1.1. No welding shall be done when base metal lower than 0 degrees F.
 - 2. Qualify welding operators in accordance with AWS D1.1.
- D. Aluminum:
 - 1. Weld with gas metal arc (GMA) or gas tungsten arc (GTA) processes in accordance with manufacturer's recommendations as accepted and in accordance with recommendations of AWS D1.2.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Store to avoid damage.
- C. Remove material that has become damaged as to be unfit for use.
- D. Identify and match-mark all materials, items, and fabrications for installation and field assembly.

1.07 FIELD MEASUREMENTS:

- A. Verify dimensions and make any field measurements necessary and be fully responsible for accuracy and layout of the work.
- B. Review the Contract Drawings and report any discrepancies to the Engineer for clarification prior to starting fabrication.

PART 2 - PRODUCTS

2.01 STEEL GRATING:

- A. Manufacturers:
 - 1. IKG Borden Metal Products Co.; Type B or W/B.
 - 2. Ohio Gratings, Inc.; Type DT or SGCS Series. (Special order required)

3. McNichols Co.; GW Series (where called for on Contract Drawings)
- B. Provide steel grating material conforming to ASTM A36.
 - C. Provide grating size as indicated on the Contract Drawings.
 - D. Fabricate in standard size sections where possible with a maximum panel weight of no more than 80 pounds.
 - E. Apply bearing bar banding at ends of grating sections and at fixture or pipe openings where two or more bearing bars are cut.
 - F. Anchor grating to support members using stainless steel saddle clips.
 - G. Exterior grating shall be serrated. Provide interior surface with mill finish.
 - H. Hot dip galvanize steel grating after fabrication in accordance with ASTM A123.
- 2.02 ALUMINUM BAR GRATING:
- A. Manufacturers:
 1. IKG Borden Metal Products Co.; Type S/B or B/F.
 2. Ohio Gratings, Inc.; Type SG or ADT Series.
 3. McNichols Co.; GAL or GAA and GBB Series.
 - B. Provide aluminum alloy 6063-T6 grating material.
 - C. Provide grating as indicated on the Contract Drawings.
 - D. Fabricate in standard size sections where possible with a maximum panel weight of no more than 80 pounds.
 - E. Apply bearing bar banding at ends of grating sections and at fixture or pipe openings where two or more bearing bars are cut.
 - F. Anchor grating to support members using stainless steel saddle clips.
 - G. Exterior grating shall be serrated. Provide interior surface with mill finish.
- 2.03 ALUMINUM COVER PLATE:
- A. Provide floor checkered plates conforming to the following aluminum alloys and tempers with a mill finish:
 1. Angles

- a. Extruded: AA 6063-T5
- b. Structural: AA 6061-T6
- 2. Checkered Plate: AA 6061-T6
- 3. Anchors Bolts, Washers, and Nuts: Stainless Steel Type 316

B. General:

- 1. Fabricate with a maximum panel weight of no more than 80 pounds.
- 2. Provide flush type lifting handles for all section of checkered plates.
- 3. Provide a raised pattern, non-skid surface.
- 4. See drawings for stiffener spacing.
- 5. Thickness as shown on contract drawings.

C. Furnish fixed cover checkered plates complete with frames, anchors, lifting handles and stainless steel flush head screw fastenings.

D. Furnish hinged checkered plate covers complete with frames, anchors, lifting handles and heavy duty hinges. Provide a minimum of two hinges of Type 316L stainless steel, with stainless steel pins and fastenings for each checkered plate section.

2.04 FLOOR ACCESS HATCHES (H-1, H-2, H-3, H-4, H-5 AND H-6):

A. Manufacturers of Prefabricated Floor Access Hatches:

- 1. USF Fabrication, Inc.
- 2. East Jordan Iron Works

B. Component Fabrication:

- 1. Provide access hatches and frames of type and size as shown on Schedule.
- 2. Where hatches are noted with curb mounting, the cover shall overlap the frame and extend down 2 inches. Provide 3/16-inch thick minimum aluminum structural angle with holes for securing to curb. Provide weathertight perimeter gasket.
- 3. Where hatches are noted with drainage channel, drainage channel frame shall be 1/4-inch thick trough frame with continuous anchor flange around perimeter. Weld 1-1/2 inch diameter drain coupling to frame trough unless indicated otherwise on Drawings.
- 4. Door leaves:

- a. 300 PSF hatches shall have 1/4-inch minimum aluminum diamond plate with reinforcing on underside for live load. Provide stainless steel safety chain and attachments for end of double-leaf door assembly when open.
 - b. 150 PSF hatches shall have 3/16-inch minimum aluminum diamond plate with reinforcing on underside for live load.
5. Door Hardware:
- a. Equip doors with heavy stainless steel hinges with stainless steel pins. Hinges shall be through bolted to cover and frame with stainless steel bolts.
 - b. Equip doors with fully enclosed compression springs and hold - open arm with positive locking device with conveniently positioned release handle for easy and controlled closing.
 - c. Hardware shall be Type 316 stainless steel.
 - d. Stainless steel snap lock mounted on bottom of door leaf with a removable topside handle and socket recessed in cover.
 - e. Hinged hasp on exterior door surface.
 - f. Cylinder lock with keyway protected by a threaded cover plug.
6. Factory finish on aluminum surfaces shall be AA-M12A41 (Mechanical finish, nonspecular, anodic coating, architectural Class I, clear coating 0.7 mil complying with AAMA 607.1 on exposed surfaces
7. Manufacturer shall warranty in writing against defects in materials or workmanship for five years.
8. Fall Protection Safety Grate:
- a. Color shall be safety orange.
 - b. Provide torsion rod lift assistance for ease of operation.
 - c. Provide an aluminum or stainless steel hold open arm to automatically lock the panel in the fully open 90 degree position.
 - d. Provide a stainless steel release handle for closing the grating panel with a provision for locking the panel to prevent unauthorized access.
 - e. All other hardware shall be Type 316 stainless steel.

2.05 CLEARWELL INSIDE ACCESS HATCH (H-7, H-8, AND H-9)

- A. Manufacturers of Prefabricated Clearwell Inside Access Hatches, or approved equal:

1. USF Fabrication, Inc.
2. Babcock Davis

B. Component Fabrication:

1. Provide access hatches and frames of type and size as shown on Contract Drawings.
2. Hatches shall have a close fitting shoebox type cover which extends down around the frame at least two inches with a gasket between the cover and the frame. The three non-hinged sides of the hatch shall be provided with adjustable cam levers (pressure locks) to tighten the cover against the gasket to ensure the hatch is watertight. Hinge fasteners must be completely concealed to inhibit tampering.
3. Door leaf: 1/4-inch Type 316 stainless steel diamond plate with reinforcing on underside for live load. Hatches shall be single leaf only.
4. Door Hardware:
 - a. Equip doors with heavy stainless steel hinges with stainless steel pins. Hinges shall be through bolted to cover and frame with stainless steel bolts.
 - b. Equip doors with fully enclosed compression springs and hold - open arm with positive locking device with conveniently positioned release handle for easy and controlled closing.
 - c. Hardware shall be Type 316 stainless steel.
 - d. The interior and exterior handles eliminated, have no penetrations in the cover, and shall have a concealed padlock hasp.
5. Manufacturer shall warranty in writing against defects in materials or workmanship for five years.
6. Fall Protection Safety Net (Ozone Contact Basin Hatches):
 - a. The hatch safety net shall be made of strong polyester netting which attaches to the frame by corrosion resistant stainless steel hardware.
7. Fall Protection Safety Grate (Main Clearwell Equipment Hatches):
 - a. Color shall be safety orange.
 - b. Provide torsion rod lift assistance for ease of operation.
 - c. Provide a stainless-steel hold open arm to automatically lock the panel in the fully open 90-degree position.

- d. Provide a stainless steel release handle for closing the grating panel with a provision for locking the panel to prevent unauthorized access.
 - e. All other hardware shall be Type 316 stainless steel.
 - C. Fall Protection Grating: Grating panel(s) shall be aluminum with a powder coat paint finish that is safety yellow in color. Panel shall be designed to meet the requirements of OSHA standard 29 CFR1926.502(c) and be equipped with a hold open device to lock the grating panel(s) in the open position. Hold open device and all hardware shall be Type 316 stainless steel.
 - D. Finishes: Factory finish shall be mill finish aluminum with bituminous coating applied to the exterior of the frame.
- 2.06 TRAFFIC RATED HATCH (H-10 AND H-11)
- A. Manufacturers of Prefabricated Traffic Rated Hatches, or approved equal:
 - 1. EJ
 - B. Component Fabrication:
 - 1. Provide access hatches and frames of type and size as shown on Contract Drawings.
 - 2. Hatches shall have a frames constructed from ASTM A536 grade 70-50-05 ductile iron and covers constructed from ASTM A536 grade 80-55-06 ductile iron.
 - C. Hatches shall be designed, tested, and rated for heavy duty daily traffic.
 - D. Hatches shall be supplied with security type hex bolt locking system capable of tightening the cover against the EPDM gasket to ensure the hatch is watertight. Hinge fasteners must be completely concealed to inhibit tampering. Hatch hardware shall be Type 316 stainless steel.
 - E. Traffic rated hatches shall be equipped with lift assist and self-engaging safety bar.
 - F. Manufacturer shall warranty in writing against defects in materials or workmanship for five years.
 - G. Fall Protection Safety Gate
 - 1. Color shall be safety orange.
 - 2. Provide torsion rod lift assistance for ease of operation.
 - 3. Provide a stainless-steel hold open arm to automatically lock the panel in the fully open 90-degree position.

4. Provide a stainless steel release handle for closing the grating panel with a provision for locking the panel to prevent unauthorized access.
 5. All other hardware shall be Type 316 stainless steel.
 6. Grating shall be designed to meet the requirements of OSHA standard 29 CFR1926.502(c)
- H. Finishes: Factory finish shall be uncoated ductile iron.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Upon receipt of material at job site, inspect all materials for shipping damage. Damaged items shall be replaced at no cost to Owner.
- B. Examine supports for size, layout, and alignment. Surface shall be free of debris.
- C. Correct defects considered detrimental to proper installation.

3.02 PROTECTION:

- A. Protect aluminum from contact with dissimilar metals or concrete. Under no circumstances shall aluminum directly contact concrete or dissimilar metal.
- B. Apply one coat of bituminous paint coating.
- C. Before coating application, clean contact surfaces, remove dirt, grease, oil, foreign substances, followed by immersing in, or wipe thoroughly with, an acceptable solvent. Rinse with clean hot water and dry thoroughly.

3.03 INSTALLATION:

- A. Install and make connections in accordance with accepted submittals and manufacturer's written instructions.
- B. Install materials accurately in location and elevation, level and plumb. Field fabricate as necessary for accurate fit.
- C. Coordinate and furnish anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors that are to be embedded in concrete or masonry construction.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

HATCH SCHEDULE

HATCH STYLE	LOCATION	CLEAR OPENING DIMENSIONS	MATERIAL	FRAME TYPE	MOUNT STYLE	LEAF	LOAD RATING	DRAIN INSTALLED	Fall Protection	Locking	Section
H-1	BACKWASH SUPPLY TANK #1	30" X 30"	ALUMINUM	ANGLE	CURB	SINGLE	150 PSF	NO	Aluminum Grating	NO	2.04
H-1	BACKWASH SUPPLY TANK #2	30" X 30"	ALUMINUM	ANGLE	CURB	SINGLE	150 PSF	NO	Aluminum Grating	NO	2.04
H-2	CIP WASTE TANK	30" X 30"	ALUMINUM	CHANNEL	FLUSH	SINGLE	300 PSF	YES	Aluminum Grating	YES	2.04
H-3	BACKWASH WASTE TANK #1	48" X 72"	ALUMINUM	CHANNEL	FLUSH	DOUBLE	300 PSF	YES	Aluminum Grating	NO	2.04
H-3	BACKWASH WASTE TANK #2	48" X 72"	ALUMINUM	CHANNEL	FLUSH	DOUBLE	300 PSF	YES	Aluminum Grating	NO	2.04
H-3	BACKWASH WASTE TANK #3	48" X 72"	ALUMINUM	CHANNEL	FLUSH	DOUBLE	300 PSF	YES	Aluminum Grating	NO	2.04
H-4	DRAIN VAULT STAIRS	42" X 120"	ALUMINUM	ANGLE	FLUSH	SINGLE	150 PSF	NO	NONE	YES	2.04
H-5	DRAIN VAULT EQUIPMENT	42" X 42"	ALUMINUM	ANGLE	FLUSH	SINGLE	150 PSF	NO	Aluminum Grating	YES	2.04
H-6	COAGULANT VAULT EQUIPMENT ACCESS	48" X 72"	ALUMINUM	CHANNEL	CURB	SINGLE	150 PSF	YES	Aluminum Grating	YES	2.04
H-7	EAST CLEARWELL OZONE BASIN	48" X 84"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	Polyester Net	YES	2.05
H-7	WEST CLEARWELL OZONE BASIN	48" X 84"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	Polyester Net	YES	2.05
H-7	CLEARWELL OVERFLOW TROUGH	48" X 84"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	Aluminum Grating	YES	2.05
H-8	EAST CLEARWELL STAIRS	42" X 132"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	NONE	YES	2.05
H-8	WEST CLEARWELL STAIRS	42" X 132"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	NONE	YES	2.05
H-9	EAST CLEARWELL EQUIPMENT	42" X 84"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	Aluminum Grating	YES	2.05
H-9	WEST CLEARWELL EQUIPMENT	42" X 84"	TYPE 316 SS	ANGLE	CURB	SINGLE	625 PSF	NO	Aluminum Grating	YES	2.05
H-10	COAGULANT VAULT ACCESS	30" X 36"	DUCTILE IRON	ANGLE	FLUSH	SINGLE	HS-20	NO	Aluminum Grating	YES	2.06
H-10	VALVE VAULT	48" X 48"	DUCTILE IRON	ANGLE	FLUSH	SINGLE	HS-20	NO	Aluminum Grating	YES	2.06
H-11	VALVE VAULT	74" X 36"	DUCTILE IRON	ANGLE	FLUSH	DOUBLE	HS-20	NO	Aluminum Grating	YES	2.06

END OF SECTION

SECTION 06 10 00
ROUGH CARPENTRY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wood products.
2. Wood-preservative-treated lumber.
3. Fire-retardant-treated lumber.
4. Miscellaneous lumber.
5. Plywood backing panels.

B. Related Requirements:

1. Section 06 16 00 "Sheathing" for sheathing, subflooring, and underlayment.

1.02 DEFINITIONS

A. Lumber grading agencies, and abbreviations used to reference them, include the following:

1. NeLMA: Northeastern Lumber Manufacturers' Association.
2. NLGA: National Lumber Grades Authority.
3. SPIB: The Southern Pine Inspection Bureau.
4. WCLIB: West Coast Lumber Inspection Bureau.
5. WWPA: Western Wood Products Association.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.

2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency in accordance with ASTM D5664.
4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.04 INFORMATIONAL SUBMITTALS

A. Material Certificates:

1. For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
2. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.

1.05 DELIVERY, STORAGE, AND HANDLING

- ##### A.
- Stack wood products flat with spacers beneath and between each bundle to provide air circulation. Protect wood products from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.01 WOOD PRODUCTS

- ##### A.
- Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
1. Factory mark each piece of lumber with grade stamp of grading agency.
 2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
 3. Dress lumber, S4S, unless otherwise indicated.

2.02 WOOD-PRESERVATIVE-TREATED LUMBER

- A. Preservative Treatment by Pressure Process: AWP A U1, Use categories as follows:
 - 1. UC3A: Coated products in exterior construction not in contact with ground but exposed to all weather cycles including intermittent wetting. Include the following items:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
 - 2. After treatment, redry wood to 19 percent maximum moisture content.
- B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or that does not comply with requirements for untreated material.
- C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

2.03 FIRE-RETARDANT-TREATED LUMBER

- A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet (3.2 m) beyond the centerline of the burners at any time during the test.
 - 1. Treatment is not to promote corrosion of metal fasteners.
 - 2. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering in accordance with ASTM D2898. Use for exterior locations and where indicated.
 - 3. Interior Type A: Treated materials are to have a moisture content of 28 percent or less when tested in accordance with ASTM D3201/D3201M at 92 percent relative humidity. Use where exterior type is not indicated.
 - 4. Design Value Adjustment Factors: Treated lumber is to be tested according to ASTM D5664 and design value adjustment factors are to be calculated according to ASTM D6841.

- C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent. Kiln-dry plywood after treatment to maximum moisture content of 15 percent.
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency and other information required by authorities having jurisdiction.
- E. Application: Treat items indicated on Drawings, and the following:
 - 1. Concealed blocking.
 - 2. Wood cants, nailers, curbs, equipment support bases, blocking, and similar members in connection with roofing.
 - 3. Plywood backing panels.

2.04 MISCELLANEOUS LUMBER

- A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.
 - 2. Nailers.
 - 3. Rooftop equipment bases and support curbs.
- B. Dimension Lumber Items: Construction or No. 2 grade lumber of any species.
- C. Roofing Nailers: Structural- or No. 2-grade lumber or better; kiln-dried Douglas fir, southern pine, or wood having similar decay-resistant properties.
- D. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

2.05 PLYWOOD BACKING PANELS

- A. Equipment Backing Panels: Plywood, DOC PS 1, Exterior, A-C, fire-retardant treated, in thickness indicated or, if not indicated, not less than 1/2-inch (13-mm) nominal thickness.

2.06 FASTENERS

- A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches (38 mm) into wood substrate.
 - 1. Where rough carpentry is in area of high relative humidity, provide fasteners of Type 304 stainless steel.

- B. Nails, Brads, and Staples: ASTM F1667.
- C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.
- B. Install plywood backing panels by fastening to studs or masonry; coordinate locations with utilities requiring backing panels. Install fire-retardant-treated plywood backing panels with classification marking of testing agency exposed to view.
- C. Provide blocking as indicated and as required to support facing materials, fixtures, specialty items, and trim.
 - 1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches (406 mm) o.c.
- D. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- E. Comply with AWPAC M4 for applying field treatment to cut surfaces of preservative-treated lumber.
 - 1. Use inorganic boron for items that are continuously protected from liquid water.
 - 2. Use copper naphthenate for items not continuously protected from liquid water.
- F. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.
- G. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - 1. Table 2304.10.1, "Fastening Schedule," in ICC's International Building Code (IBC).
 - 2. ICC-ES evaluation report for fastener.

- H. Securely attach roofing nailers to substrates by anchoring and fastening to withstand bending, shear, or other stresses imparted by Project wind loads and fastener-resistance loads as designed in accordance with ASCE/SEI 7.
- I. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.02 INSTALLATION OF WOOD BLOCKING AND NAILERS

- A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
- B. Attach wood blocking to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.
- C. Attach wood roofing nailers securely to substrate to resist the designed outward and upward wind loads indicated on Drawings and in accordance with ANSI/SPRI ED-1, Tables A6 and A7.

END OF SECTION

SECTION 06 16 00

SHEATHING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wall and parapet sheathing.

B. Related Requirements:

1. Section 06 10 00 "Rough Carpentry" for plywood backing panels.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Wall and parapet sheathing.

B. Product Data Submittals: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

C. Shop Drawings:

1. Show locations and extent of sheathing, accessories, and assemblies specific to Project conditions.
2. Include details for sheathing joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.01 WALL AND PARAPET SHEATHING

A. Glass-Mat Gypsum Sheathing: ASTM C1177/C1177M.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Certainteed; SAINT-GOBAIN.
 - b. Continental Building Products Inc.
 - c. Gold Bond Building Products, LLC provided by National Gypsum Company.
 - d. USG Corporation.
2. Type and Thickness: Type X, 5/8 inch (15.9 mm) thick, unless otherwise indicated.

2.02 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
1. For parapet and wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M or of Type 304 stainless steel.
- B. Nails, Brads, and Staples: ASTM F1667.
- C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- D. Screws for Fastening Gypsum Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing to be attached.
1. For steel framing less than 0.0329 inch (0.835 mm) thick, use screws that comply with ASTM C1002.
 2. For steel framing from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick, use screws that comply with ASTM C954.

2.03 SHEATHING JOINT-AND-PENETRATION TREATMENT MATERIALS

- A. Sealant for Paper-Surfaced and Glass-Mat Gypsum Sheathing: Elastomeric, medium-modulus, neutral-curing silicone joint sealant compatible with joint substrates formed by gypsum sheathing and other materials, recommended by sheathing manufacturer for application indicated and complying with requirements for elastomeric sealants specified in Section 07 92 00.
- B. Sealant for Glass-Mat Gypsum Sheathing: Silicone emulsion sealant complying with ASTM C834, compatible with sheathing tape and sheathing and recommended by tape and sheathing manufacturers for use with glass-fiber sheathing tape and for covering exposed fasteners.
1. Sheathing Tape: Self-adhering glass-fiber tape, minimum 2 inches (50 mm) wide, 10 by 10 or 10 by 20 threads/inch (390 by 390 or 390 by 780 threads/m), of type recommended by sheathing and tape manufacturers for use with silicone emulsion

sealant in sealing joints in glass-mat gypsum sheathing and with a history of successful in-service use.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- C. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. Table 2304.10.1, "Fastening Schedule," in the ICC's International Building Code.
 - 2. ICC-ES evaluation report for fastener.
- D. Retain first paragraph below if using wood framing. Revise to indicate other kinds of nails if required.
- E. Use common wire nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections. Install fasteners without splitting wood.
- F. Coordinate parapet and wall sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.
- G. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.
- H. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.02 INSTALLATION OF GYPSUM SHEATHING

- A. Comply with GA-253 and with manufacturer's written instructions.
 - 1. Fasten gypsum sheathing to cold-formed metal framing with screws.
 - 2. Install panels with a 3/8-inch (9.5-mm) gap where non-load-bearing construction abuts structural elements.

3. Install panels with a 1/4-inch (6.4-mm) gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.
- B. Apply fasteners so heads bear tightly against face of sheathing, but do not cut into facing.
- C. Seal sheathing joints in accordance with sheathing manufacturer's written instructions.
1. Apply elastomeric sealant to joints and fasteners and trowel flat. Apply sufficient amount of sealant to completely cover joints and fasteners after troweling. Seal other penetrations and openings.
 2. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing joints and apply and trowel sealant to embed entire face of tape in sealant. Apply sealant to exposed fasteners with a trowel so fasteners are completely covered. Seal other penetrations and openings.

END OF SECTION

SECTION 06 41 16

PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Plastic-laminate-clad architectural cabinets.
2. Cabinet hardware and accessories.
3. Miscellaneous materials.

B. Related Requirements:

1. Section 06 10 00 for wood furring, blocking, shims, and hanging strips required for installing cabinets that are concealed within other construction before cabinet installation.
2. Section 12 36 61.16.

1.02 COORDINATION

- ###### A.
- Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to support loads imposed by installed and fully loaded cabinets.

1.03 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Show large-scale details.
3. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
4. Show locations and sizes of cutouts and holes for items installed in plastic-laminate architectural cabinets.

C. Samples for Initial Selection: For each type of exposed finish.

D. Samples for Verification: For the following:

1. Plastic Laminates: 12 by 12 inches (300 by 300 mm), for each type, color, pattern, and surface finish required.
 - a. Provide one sample applied to core material with specified edge material applied to one edge.
2. Exposed Cabinet Hardware and Accessories: One full-size unit for each type and finish.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer and Installer.
- B. Product Certificates: For each type of product.

1.05 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.
- B. Installer Qualifications: Manufacturer of products.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver cabinets until painting and similar finish operations that might damage architectural cabinets have been completed in installation areas. Store cabinets in installation areas or in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.

1.07 FIELD CONDITIONS

- A. Environmental Limitations without Humidity Control: Do not deliver or install cabinets until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature and relative humidity at levels planned for building occupants during the remainder of the construction period.
- B. Field Measurements: Where cabinets are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 1. Locate concealed framing, blocking, and reinforcements that support cabinets by field measurements before being enclosed/concealed by construction, and indicate measurements on Shop Drawings.

- C. Established Dimensions: Where cabinets are indicated to fit to other construction, establish dimensions for areas where cabinets are to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

PART 2 - PRODUCTS

2.01 PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

- A. Quality Standard: Unless otherwise indicated, comply with the Architectural Woodwork Standards for grades of cabinets indicated for construction, finishes, installation, and other requirements.
- B. Architectural Woodwork Standards Grade: Custom.
- C. High-Pressure Decorative Laminate: ISO 4586-3, grades as indicated or if not indicated, as required by quality standard.
- D. Exposed Surfaces:
 - 1. Plastic-Laminate Grade: HGS.
 - 2. Edges: PVC T-mold matching laminate in color, pattern, and finish.
- E. Semiexposed Surfaces:
 - 1. Surfaces Other Than Drawer Bodies: High-pressure decorative laminate, ISO 4586-3.
 - a. Edges of Plastic-Laminate Shelves: PVC T-mold matching laminate in color, pattern, and finish.
 - b. For semiexposed backs of panels with exposed plastic-laminate surfaces, provide surface of high-pressure decorative laminate, ISO 4586-3, grade to match exposed surface.
 - 2. Drawer Sides and Backs: Solid-hardwood lumber.
 - 3. Drawer Bottoms: Hardwood plywood.
- F. Dust Panels: 1/4-inch (6.4-mm) plywood or tempered hardboard above compartments and drawers unless located directly under tops.
- G. Concealed Backs of Panels with Exposed Plastic-Laminate Surfaces: High-pressure decorative laminate, ISO 4583-3, grade to match exposed surface.
- H. Drawer Construction: Fabricate with exposed fronts fastened to subfront with mounting screws from interior of body.

1. Join subfronts, backs, and sides with glued dovetail joints.

I. Colors, Patterns, and Finishes: Provide materials and products that result in colors and textures of exposed laminate surfaces complying with the following requirements:

1. Refer to Drawings.

2.02 WOOD MATERIALS

A. Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of architectural cabinet and quality grade specified unless otherwise indicated.

1. Wood Moisture Content: 4 to 9 percent.

B. Composite Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of architectural cabinet and quality grade specified unless otherwise indicated.

1. Medium-Density Fiberboard (MDF): ANSI A208.2, Grade 130.

2. Particleboard (Medium Density): ANSI A208.1, Grade M-2.

3. Softwood Plywood: DOC PS 1, medium-density overlay.

2.03 CABINET HARDWARE AND ACCESSORIES

A. Butt Hinges: 2-3/4-inch (70-mm), five-knuckle steel hinges made from 0.095-inch-(2.4-mm-) thick metal, and as follows:

B. Wire Pulls: Back mounted, solid metal, 5 inches (127 mm) long, 2-1/2 inches (63.5 mm) deep, and 5/16 inch (8 mm) in diameter.

C. Catches: Push-in magnetic catches, ANSI/BHMA A156.9, B03131.

D. Adjustable Shelf Standards and Supports: ANSI/BHMA A156.9, B04071; with shelf rests, B04081.

E. Shelf Rests: ANSI/BHMA A156.9, B04013; metal.

F. Drawer Slides: ANSI/BHMA A156.9.

1. Heavy-Duty (Grade 1HD-100 and Grade 1HD-200): Side mount or Undermount.

a. Type: Full extension.

b. Material: Aluminum, Galvanized steel ball bearing, Stainless steel, or Zinc-plated ball bearing slides.

2. General-purpose drawers more than 3 inches (75 mm) high, but not more than 6 inches (150 mm) high and not more than 24 inches (600 mm) wide, provide 75 lb (34 kg) load capacity.
 3. File drawers more than 6 inches (150 mm) high or more than 24 inches (600 mm) wide, provide 100 lb (45 kg) load capacity.
- G. Door and Drawer Silencers: ANSI/BHMA A156.16, L03011.
- H. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with ANSI/BHMA A156.18 for ANSI/BHMA finish number indicated.
1. Satin Stainless Steel: ANSI/BHMA 630.
- I. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in ANSI/BHMA A156.9.
- 2.04 MISCELLANEOUS MATERIALS
- A. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.
- B. Adhesive for Bonding Plastic Laminate: Type II water-resistant type as selected by fabricator to comply with requirements.
1. Adhesive for Bonding Edges: Hot-melt adhesive or adhesive specified above for faces.
- 2.05 FABRICATION
- A. Fabricate architectural cabinets to dimensions, profiles, and details indicated.
- B. Complete fabrication, including assembly and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
- C. Shop-cut openings to maximum extent possible to receive hardware, appliances, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Before installation, condition cabinets to humidity conditions in installation areas for not less than 72 hours.

3.02 INSTALLATION

- A. Architectural Woodwork Standards Grade: Install cabinets to comply with quality standard grade of item to be installed.
- B. Assemble cabinets and complete fabrication at Project site to extent that it was not completed in the shop.
- C. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Secure with wafer-head cabinet installation screws.
- D. Install cabinets level, plumb, and true in line to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm) using concealed shims.
 - 1. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
 - 2. Install cabinets without distortion so doors and drawers fit openings and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.
 - 3. Fasten wall cabinets through back, near top and bottom, and at ends not more than 16 inches (400 mm) o.c.

3.03 ADJUSTING AND CLEANING

- A. Repair damaged and defective cabinets, where possible, to eliminate functional and visual defects. Where not possible to repair, replace architectural cabinets. Adjust joinery for uniform appearance.
- B. Clean, lubricate, and adjust hardware.
- C. Clean cabinets on exposed and semiexposed surfaces.

END OF SECTION

SECTION 06 51 00.01

FIBERGLASS REINFORCED PLASTIC (FRP) BAFFLES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test fiberglass baffles and appurtenances as indicated and in compliance with Contract Documents which includes, but is not limited to:
 - 1. FRP Baffle Wall Panels
 - 2. FRP Columns
 - 3. FRP Wall Angles
 - 4. Column Base Plates
 - 5. Fasteners and Connections

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. D256: Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
 - 2. D570: Standard Test Method for Water Absorption of Plastics
 - 3. D638: Standard Test Method for Tensile Properties of Plastics
 - 4. D696: Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 Degree C and 30 Degree C with a Vitreous Silica Dilatometer
 - 5. D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - 6. D2583: Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
- B. NSF International (NSF):
 - 1. ANSI/NSF 61: Drinking Water System Components - Health Effects

1.03 DESIGN CRITERIA

- A. Design load, considered as uniform loading over the entire wall, shall include fluid flow pressure plus any dynamic pressure associated with mechanical equipment. Actual load requirements, which vary with process, shall be specified by the Design Engineer.
 - 1. Design Load: Load for design shall be the greater of water differential or wind load but not a combination of the two.
 - a. Water Differential: 2 inches, w.c. (Considered as a uniform load over the entire wall)
 - 2. Deflection Limits and Factors of Safety
 - a. Baffle Panels: $L/D = 90$ (not to exceed panel depth); Factor of Safety = 2.0
 - b. Columns: $L/D = 100$, Factor of Safety = 2.5

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Layout drawings and design calculations stamped and signed by a professional engineer licensed in the State of Utah.
 - 2. Materials listing including resins and fiberglass content and thicknesses. List the Type of resins manufacturer, composition, and characteristic.
 - 3. Method of attachment, size of fasteners and weights of each section.
 - 4. Dimensions and thickness of all fiberglass components.
 - 5. Shop drawing data for accessory items.
 - 6. Certified setting plans, with tolerances, for anchor bolts.
 - 7. Manufacturer's literature as needed to supplement certified data.
 - 8. Operating and maintenance instructions and parts lists.
 - 9. Listing of reference installations as specified with contact names and telephone numbers.
 - 10. Shop and field inspection reports.
 - 11. Shop test results: Certified test reports of the physical and mechanical properties as specified herein.
 - 12. Qualifications of field service engineer.

13. Recommendations for short and long-term storage.
 14. Special tools.
 15. Number of service person-days provided and per diem field service rate.
 16. The latest ISO 9001 series certification.
 17. NSF 61 approval
 18. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
 - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
- B. A copy of the contract mechanical process and structural drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with “No changes required” or provide a statement that no changes are required.
1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
- C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in

submittal return without review until marked up specifications and justifications are submitted in a complete package.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Baffle wall system shall be the product of one manufacturer to ensure coordination and compatibility of parts.
- C. Manufacturer of baffle wall system must be the Manufacturer and Fabricator of fiberglass components utilized in the baffle system. The manufacturer of the fiberglass components shall take full responsibility for products, materials, and design. In addition, a certification letter from the Manufacturer shall state that Manufacturer takes full responsibility for design and use of products as specified. No split responsibility of product manufacturing, fabrication, design, or quality of fiberglass components purchased by Contractor will be acceptable.
- D. Supplier of baffle wall system shall manufacture and fabricate all fiberglass components utilized for baffle wall system in its own facility, which must be ISO9001 certified.
- E. Warranty: Provide a two (2) year warrantee from material and workmanship defects.
- F. Manufacturer of baffle wall system shall have completed within the last five years a minimum of five (5) projects of similar type as those required in this scope.
- G. Contractor shall be responsible for verifying all field dimensions for development and approval of manufacturer's drawings.
- H. Coordination: Baffle manufacturer shall coordinate the fabrication of the baffles with the contractor in regard to the Clearwell configurations.
- I. Services of Manufacturer's Representative as stated in Section 01 61 00 and as specified herein.
- J. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 - 2. Installation: Inspect location of anchor bolts; setting, leveling, alignment and field erection:
 - a. 1/2 person-day per Clearwell.

3. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment, or material shall be provided at no additional cost to the Owner.

K. All components used in a water treatment process must be NSF 61 approved.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. The standard for design, characteristics, and performance shall be based on materials and components provided by Enduro Composites, Inc.
- B. Should equipment which differs from the first named in this Section be offered, such equipment shall be acceptable only on the basis that they meet this Specification in full and any revision in the design and/or construction of the structure, piping, appurtenant equipment required to accommodate such a substitution shall be made at no additional cost to the Owner and be as approved by the Engineer.
- C. FRP Baffle manufacturer shall be:
1. Enduro Composites, Inc.
 2. NEFCO
 3. Or approved equal

2.02 MATERIALS:

- A. Fiberglass -reinforced polyester plastic, molded by "matched-die" or acceptable equivalent method.
- B. Baffle panels, FRP columns, FRP angles, and associated components shall be ANSI/NSF Standard 61 certified for potable water application.
1. Certification shall be by approved, independent third party, and in Baffle Manufacturer's name.
 2. Certifications of raw materials, not in Baffle Manufacturer's name, shall not be acceptable.
- C. Minimum physical properties.

Minimum Physical Laminate	Minimum Value	Test Method
Tensile strength	40,000 psi	ASTM D638
Flexural strength	32,000 psi	ASTM D790
Flexural modulus	1,035,000 psi	ASTM D790
Impact, Notches, Izod, foot pound per inch	15	ASTM D256
Barcol Hardness (average)	Barcol 40	ASTM D2583
Average coefficient of thermal expansion – inch per inch, per degrees F	16×10^{-6}	ASTM D696
Water absorption (percent 24 hr)	0.02	ASTM D570

D. Make hardness tests on the resin-rich surfaces of the test sample. Test samples type, preparation, and conformance to the requirements of the ASTM test methods designated above.

E. Minimum glass content: 30 percent.

1. Molding process to produce a uniform, smooth finish free of porous or dry areas and voids.
2. Mold edges of plates, holes, and notches into the plates at the factory.

F. Air bubbles and other irregularities, including pits, will be cause for rejection.

G. Materials in contact with the water shall not impart any substances harmful to health or detrimental to the quality of the water and shall not impart any taste or odor to the water.

2.03 FRP BAFFLE PANELS:

A. Provide baffle panels of the sizes and lengths as indicated on the Contract Drawings and as specified.

1. FRP baffle panels shall be ribbed profile in 4-inch depth x 26-inch height coverage (full panel dimension).
2. FRP baffle panels shall be minimum of 1/8-inch (0.125 inch) thick.
3. FRP baffle panels shall have (top) horizontal ribs that slope to minimize sediment build-up.
4. FRP baffle panels shall comply with the structural requirements in Part 1. 1.05 Design Criteria.
5. FRP material shall include glass fiber reinforcements 40% (minimum) of the material weight embedded within UV Stabilized, Polyester Resin. Color shall be standard gray.

6. FRP material shall have surfacing veil on both sides.
7. Factory cut edges and drilled holes shall be sealed with ANSI/NSF 61 approved material.

2.04 FRP STRUCTURAL FRAMING AND ANGLES

- A. Provide structural framing and angles of the sizes and lengths as required per the manufacturer's design calculations.
 1. FRP framing shall comply with the structural requirements in Part 1. 1.05 Design Criteria.
 2. FRP vertical columns may be anchored into the floor slab and roof deck. Both the floor slab and roof decks are sloping.
 3. FRP angles shall be a minimum of 3/8" (0.375 inch) thickness and 90 degrees.
 4. Manufacturer shall factory attach FRP angles to FRP columns (as applicable).
 5. Installing contractor shall field attach FRP angles to concrete structure.
 6. FRP material shall include glass fiber reinforcements 50% (minimum) of the material weight embedded within UV Stabilized, Polyester Resin. Color shall be standard gray.
 7. FRP material shall have surfacing veil on both top and bottom sides.
 8. Factory cut edges and drilled holes shall be sealed with ANSI/NSF 61 approved material.

2.05 OTHER STRUCTURAL COMPONENTS

- A. Provide other structural components of the sizes and lengths as required per the manufacturer's design calculations.
 1. Column base plates or angles shall be Type 316 Stainless Steel
 2. Base plates or angles (shall be field attached unless noted otherwise on drawings.
 3. Base plates made of FRP shall not be allowed.
 4. Base plates must be a full moment connection.

2.06 HARDWARE

- A. Fasteners, anchorage, and other structural hardware shall be Type 316 Stainless Steel and shall be provided, sized, and designed by the Baffle Wall Manufacturer.

- B. All submerged anchors shall be epoxy adhesive type meeting NSF 61 requirements (size as required).

PART 3 - EXECUTION

3.01 MATERIAL HANDLING

- A. At the time of delivery, all materials shall be inspected for shipping damage. Freight company and Manufacturer shall be notified immediately of any damage or quantity shortages.
- B. Contractor shall protect FRP materials from cuts, scratches, gouges, abrasions, and impacts. When lifting crated FRP materials, spreader bars shall be used (not wire slings or chains unless materials are fully protected). FRP components shall not be dragged across one another unless separated by a non-scratching spacer.

3.02 INSTALLATION:

- A. Install items in accordance with accepted shop drawings, manufacturer's printed instructions and as indicated.
- B. Before placing and attaching components, Contractor shall confirm the alignment and location of column base plates, surfaces, brackets, saddles, etc. All bearing surfaces must be level, flat, clean, and free of debris.
- C. Contractor shall install pads, curbs or piers to modify uneven or sloped concrete surfaces to create a flat, level surface for baffle system attachment.
- D. Contractor shall field cut materials as required and shown on the Manufacturer's drawings.
- E. Use factory drilled mounting holes. Field cutting will only be allowed as accepted by the Engineer to complete the structure and accommodate in-tank obstructions.
- F. Coat all field cut or drilled edges in accordance with the manufacturer's recommendations to prevent fiberblossoming or fraying with an NSF 61 approved material.
- G. Accurately set embedded items using templates.
- H. Contractor shall install beams and connections as shown on the approved layout drawings. Field modifications (cuts, copes, holes, etc.) unless shown on the drawings are not allowed without the manufacturer's written approval. Shim FRP beams with approved materials only.

- I. Before placement of baffle panels, contractor shall check alignment and location of FRP framing members and existing structure. Baffle panels shall be nested at side-lap conditions.
 - J. Contractor shall adjust FRP baffle panels for proper bearing and alignment. The first panel installed at the bottom of the wall must have the side with a flat end (not an upturn) at the bottom.
 - K. Contractor shall drill holes for fasteners through baffle panel and support beam. Coat with NSF 61 material per paragraph 3.02.F above.
 - L. Contractor shall fasten baffle panels to structural supports as shown on the approved layout drawings. Unless noted otherwise, FRP baffle panels shall be attached to each support with a minimum of three (3) nut and bolt assemblies with minimum 1.25-inch diameter Fender washers. At panel side laps, fastening shall be through two panels. Refer to manufacturer's installation instructions and drawings for proper fastener selection and procedure.
 - M. Contractor shall place and fasten other miscellaneous components or hardware as shown on the approved drawings.
 - N. Erect all equipment in conformity with accepted high-quality standards, using skilled workmen of the appropriate trades.
- 3.03 CONTRACT CLOSEOUT:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 06 60 10

FIBERGLASS REINFORCED PRODUCTS AND FABRICATIONS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section includes:

1. FRP Grating and Treads
2. Molded Grating
3. FRP Structural Shapes
4. FRP Stairs
5. FRP Railing

B. Furnish all labor, materials, equipment and incidentals necessary to install the fiberglass polymer products as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

A. ASTM International (ASTM):

1. D70: Standard Test Method for Density of Semi-Solid Bituminous Materials (Pycnometer Method).
2. D256: Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
3. D635: Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
4. D638: Standard Test Method for Tensile Properties of Plastics.
5. D695: Standard Test Method for Compressive Properties of Rigid Plastics.
6. D696: Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 Degree C and 30 Degree C with a Vitreous Silica Dilatometer.
7. D732: Standard Test Method for Shear Strength of Plastics by Punch Tool.
8. D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

9. D792: Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
10. D2583: Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
11. D3918: Standard Terminology Relating to Reinforced Plastic Pultruded Products.
12. E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
13. G152: Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
14. G153: Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Detail shop drawings indicating:
 - a. Dimensions
 - b. Sectional assembly
 - c. Location and identification mark
 - d. Connections, connections to structure and fastening methods
 - e. Size and location of supporting frames required
 - f. Materials of construction
 - g. Installation instructions
2. Catalog data and design tables showing limits for span length and deflection under various and concentrated loads.
3. Stamped by Professional Engineer registered in State where the project is located.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Furnish material from an ISO-9001 certified manufacturer of proven ability who has regularly engaged in the manufacture and installation of FRP systems.

C. Provide documentation showing that the Contractor doing this work has a minimum of 5 years' experience in the manufacture and installation of FRP systems similar to that indicated for this project, with sufficient capacity to produce required units without causing delay of work.

D. Install materials in accordance with the manufacturer's instructions.

1.05 DELIVERY STORAGE AND HANDLING:

A. Comply with the requirements specified in Section 01 66 10.

B. Store materials during and after shipment to prevent cracking, twisting, bending, breaking, chipping or damage of any kind to materials, including damage due to over exposure to sun.

C. Remove material that is damaged from the site, at no cost to the Owner.

D. Identify and match-mark all materials, items, and fabrications for installation and field assembly.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Seasafe, Inc.

B. Strongwell

C. IMCO Reinforced Plastics, Inc.

D. International Grating, Inc.

E. Fibergrate Composite Structures, Inc.

F. If the Contractor chooses to substitute equipment other than a named manufacturer, any additional costs required to accommodate such equipment shall be made without a change in the Contract Price or Contract Time and at no additional cost to the Owner.

2.02 GENERAL:

A. Provide new materials free from defects and imperfections that might affect performance of finished product.

B. After fabrication, seal cut ends, holes and abrasions of FRP shapes with a compatible resin coating to prevent intrusion of corrosion and moisture.

C. Fabricate so that exposed surfaces are smooth and true to form.

- D. Manufacture FRP products using vinyl ester resin with flame retardant and UV inhibitor additives. Provide synthetic surface veil covering exterior surface. Provide FRP shapes with flame spread of 25 or less in accordance with ASTM E84.
- E. Provide FRP products exposed to weather with ultraviolet inhibitor and one mil thick UV coating to shield from ultra-violet light.
- F. Provide Type 316L stainless steel metal accessories unless noted otherwise. Provide concrete anchors that comply with Section 05 50 00.

2.03 FRP GRATING AND STAIR TREADS:

A. Design Requirements:

1. Grating:

- a. Design grating and support system to sustain dead loads and superimposed live loads.
- b. 100 psf uniform live load or 300 pound concentrated live load, whichever produces maximum stress.

2. Stair Treads:

- a. 100 psf uniform live load or 300 pound concentrated live load on an area of 4 square inches located in the center of the tread, whichever produces greater stress.

3. Deflection:

- a. 1/4-inch maximum under uniform live load of 100 psf for grating and stair treads
- b. Span: $L/240$ maximum for support members

- B. Fabricate grating and Stair Treads from pultruded bearing bars and cross rods. Assemble grating using a locking cross-rod design that makes a permanent connection between the cross-rod and bearing bar, and is completely bond into a one-piece panel.
- C. Color shall be gray. Stair treads shall have a safety yellow nosing.
- D. Provide grating with a slip resistant epoxy grit surface.
- E. Use Type 316L stainless steel grating hold down clamps spaced as required by manufacturer, but not greater than 4 feet on center. Provide two at each support with a minimum of four per panel.

- F. At roof walkway locations provide rubber feet by grating manufacture between roofing and bottom of grating, spaced as required by manufacturer, but no greater than 4 feet on center. Provide minimum of 4 per panel
- G. Position grating sections flat and square with ends bearing minimum 1-1/4 inches on supporting structure.
- H. Provide embedded angle support frames with continuous integral anchor for grating set in concrete openings unless noted otherwise.
- I. Maximum Grating Clearances:
 - 1. 1/4-inches from vertical steel sections
 - 2. 1/2-inches from concrete and masonry walls
 - 3. 1/4-inches between sections and at ends

2.04 MOLDED GRATING:

- A. Design Requirements:
 - 1. Grating:
 - a. Design grating and support system to sustain dead loads and superimposed live loads.
 - b. 100 psf uniform live load or 300 pound concentrated live load, whichever produces maximum stress.
 - 2. Deflection:
 - a. 1/4-inches maximum under uniform live load of 100 psf for grating.
 - b. Span: L/240 maximum for support members.
- B. Continuous glass filament reinforcement, approximately 30 percent glass to resin ratio.
- C. Resin rich exterior surfaces free of air bubbles and dry glass.
- D. Color shall be gray.
- E. Provide a slip resistant quartz grit applied surface.
- F. Provide Type 316L stainless steel hold down clamps spaced as required by manufacturer, but not greater than 4 feet on center. Provide two at each support with a minimum of four per panel.

- G. Position grating sections flat and square with ends bearing minimum 1-1/4 inches on supporting structure.
- H. Set grating set in concrete openings with embedded angle support frames having continuous integral anchor.
- I. Maximum Grating Clearances:
 - 1. 1/4-inches from vertical steel sections.
 - 2. 1/2-inches from concrete and masonry walls.
 - 3. 1/4-inches between sections and at ends

2.05 STRUCTURAL SHAPES:

- A. Design requirements:
 - 1. Design Loads:
 - a. Design structural framing to sustain dead loads and superimposed live loads.
 - b. 100 psf uniform live load or 300 pound concentrated live load, whichever produces maximum stress.
 - 2. Deflection:
 - a. Span: $L/240$ maximum
- B. Manufacture structural shapes by the pultrusion process.
- C. Provide structural shapes with a UV inhibitor.
- D. Provide structural shapes containing a glass fiber reinforced polyester ester resin matrix, approximately 50 percent glass by weight with a synthetic surface veil outer layer covering the exterior surfaces. Provide glass strand rovings shall be for longitudinal strength. Provide continuous strand glass mats or stitched reinforcements shall for transverse strength.
- E. Provide Type 316L stainless steel bolts and washers.
- F. Abrade joint surfaces to be bonded to remove surface gloss and be free of burrs or other foreign materials that would prevent proper adhesion.

2.06 STAIRS:

- A. Fabricate from FRP structural shapes form material as specified.
- B. If rise and runs are not noted on Drawings, use OSHA standards for rise and run.

- C. Provide Stair Treads from material as specified.
- D. Provide handrail from material as specified.
- E. Use Type 316 stainless steel bolts throughout.

2.07 RAILING:

- A. Design Requirement:
 - 1. Design railing system to meet the configuration and loading requirements of OSHA, IBC or local buildings codes. Apply requirements of the most stringent code.
- B. Fully bond all post to rail connections with an epoxy adhesive and with an internal connection for added strength and durability. Provide smooth transitions between post and rail connections.
- C. Provide kickplates where required by OSHA. Kick plate shall be 4 inches by 1/2-inch (corrugated) by 1/4-inch thick pultruded shape attached to posts with stainless connectors.
- D. Color shall be safety yellow.
- E. Fabricate handrail to standard two-rail design unless noted otherwise.
 - 1. Post Locations:
 - a. No greater than 12 inches from horizontal or vertical change in handrail direction.
 - b. Post centers shall be no greater than 60 inches apart on any straight run of rail.
 - c. Post centers shall be no greater than 48 inches apart on inclined rail section.
- F. Provide side mounted, base mounted, embedded, or removable anchorage mounted handrail as noted on Drawings.
- G. Accurately locate handrail sections and erect plumb and level.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Remove and replace damaged items at no cost to Owner.
- B. Examine supports for size, layout and alignment. Maintain surfaces free of debris.

3.02 INSTALLATION:

- A. Install and make connections in accordance with accepted submittals and manufacturer's written instructions.
- B. Install materials accurately in location and elevation, level and plumb. Field fabricate as necessary for accurate fit.
- C. Coordinate and furnish anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors that are to be embedded in concrete or masonry construction.

3.03 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 07 14 16

COLD FLUID-APPLIED WATERPROOFING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Polyurethane waterproofing.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review waterproofing requirements including, but not limited to, the following:
 - a. Surface preparation specified in other Sections.
 - b. Minimum curing period.
 - c. Forecasted weather conditions.
 - d. Special details and sheet flashings.
 - e. Repairs.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and tested physical and performance properties of waterproofing.
2. Include manufacturer's written instructions for evaluating, preparing, and treating substrate.

B. Shop Drawings:

1. Indicate locations and extent of waterproofing.
2. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field quality-control reports.
- C. Sample Warranties: For special warranties.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.

1.06 FIELD CONDITIONS

- A. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended in writing by waterproofing manufacturer.
 - 1. Do not apply waterproofing to a damp or wet substrate, when relative humidity exceeds 85 percent, or when temperatures are less than 5 deg F (3 deg C) above dew point.
 - 2. Do not apply waterproofing in snow, rain, fog or mist, or when such weather conditions are imminent during application and curing period.
- B. Maintain adequate ventilation during application and curing of waterproofing materials.

1.07 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace waterproofing that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain waterproofing materials, protection course, from single source and from single manufacturer.

2.02 POLYURETHANE WATERPROOFING

- A. Single-Component, Modified Polyurethane Waterproofing: ASTM C836/C836M and coal-tar free.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CETCO is a subsidiary of Minerals Technologies Inc.
 - b. Carlisle Coatings & Waterproofing Inc.
 - c. Master Builders Solutions.
 - d. Tremco Incorporated.

2.03 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials recommended in writing by waterproofing manufacturer for intended use and compatible with one another and with waterproofing.
 1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.
- B. Primer: Manufacturer's standard primer, sealer, or surface conditioner; factory-formulated.
- C. Sheet Flashing: 50-mil- (1.3-mm-) minimum, nonstaining, uncured sheet neoprene.
 1. Adhesive: Manufacturer's recommended contact adhesive.
- D. Joint Reinforcing Strip: Manufacturer's recommended fiberglass mesh or polyester fabric.
- E. Joint Sealant: Multicomponent polyurethane sealant, compatible with waterproofing; ASTM C920, Type M, Class 25 or greater; Grade NS for sloping and vertical applications; Use NT exposure; and as recommended by manufacturer for substrate and joint conditions.
 1. Backer Rod: Closed-cell polyethylene foam.
- F. Protection Course: Manufacturer's recommended protection course for vertical applications.

2.04 INSULATION

- A. Insulation: Comply with Section 07 21 00 for general building insulation, including foundation insulation.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
 - 1. Verify that concrete has cured and aged for minimum time period recommended in writing by waterproofing manufacturer.
 - 2. Verify that substrate is visibly dry and within the moisture limits recommended in writing by manufacturer. Test for capillary moisture by plastic sheet method in accordance with ASTM D4263.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean, prepare, and treat substrates in accordance with manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.
- B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.
- C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, acid residues, and other penetrating contaminants or film-forming coatings from concrete.
- D. Remove fins, ridges, and other projections, and fill honeycomb, aggregate pockets, holes, and other voids.

3.03 PREPARATION AT TERMINATIONS, PENETRATIONS, AND CORNERS

- A. Prepare surfaces at terminations and penetrations through waterproofing and at expansion joints, drains, sleeves, and corners in accordance with waterproofing manufacturer's written instructions and to recommendations in ASTM C1471/C1471M.
- B. Apply waterproofing in two separate applications, and embed a joint reinforcing strip in the first preparation coat when recommended by waterproofing manufacturer.

3.04 JOINT AND CRACK TREATMENT

- A. Prepare, treat, rout, and fill joints and cracks in substrate in accordance with waterproofing manufacturer's written instructions and to recommendations in ASTM C1471/C1471M. Before coating surfaces, remove dust and dirt from joints and cracks in accordance with ASTM D4258.
- B. Install sheet flashing and bond to deck and wall substrates where required in accordance with waterproofing manufacturer's written instructions.

3.05 INSTALLATION OF WATERPROOFING

- A. Apply waterproofing in accordance with manufacturer's written instructions and to recommendations in ASTM C1471/C1471M.
- B. Start installing waterproofing in presence of manufacturer's technical representative.

3.06 PROTECTION

- A. Protect waterproofing from damage and wear during remainder of construction period.
- B. Protect installed insulation drainage panels from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
- C. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.

END OF SECTION

SECTION 07 19 00
WATER REPELLENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Penetrating water repellents.

B. Related Requirements:

1. Section 04 20 00 for integral water-repellent admixture for unit masonry assemblies.

1.02 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

A. Product Data Submittals:

1. Include manufacturer's printed statement of VOC content.
2. Include manufacturer's recommended number of coats for each type of substrate and spreading rate for each separate coat.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Applicator.
- B. Product Certificates: For each type of water repellent.
- C. Preconstruction Test Reports: For water-repellent-treated substrates.
- D. Field quality-control reports.
- E. Sample Warranty: For special warranty.

1.05 QUALITY ASSURANCE

- A. Applicator Qualifications: An employer of workers trained and approved by manufacturer.
- B. Mockups: Prepare mockups of each required water repellent on each type of substrate required to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Apply to mockup shown on Drawings and as specified in Section 01 43 39 "Mockups."
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.

1.06 FIELD CONDITIONS

- A. Limitations: Proceed with application only when the following existing and forecasted weather and substrate conditions permit water repellents to be applied in accordance with manufacturers' written instructions and warranty requirements:
 1. Concrete surfaces and mortar have cured for not less than 28 days.
 2. Building has been closed in for not less than 30 days before treating wall assemblies.
 3. Ambient temperature is above 40 deg F (4.4 deg C) and below 100 deg F (37.8 deg C) and will remain so for 24 hours.
 4. Substrate is not frozen and substrate-surface temperature is above 40 deg F (4.4 deg C) and below 100 deg F (37.8 deg C).
 5. Rain or snow is not predicted within 24 hours.
 6. Not less than 24 hours have passed since surfaces were last wet.
 7. Windy conditions do not exist that might cause water repellent to be blown onto vegetation or surfaces not intended to be treated.

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and Applicator agree(s) to repair or replace materials that fail to maintain water repellency specified in "Performance Requirements" Article within specified warranty period.
 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Performance: Water repellents must meet the following performance requirements as determined by testing on substrates representing those indicated for this Project.
- B. Water Absorption: Minimum 90 percent reduction of water absorption after 24 hours for treated compared to untreated specimens when tested according to the following:

1. Concrete Masonry Units: ASTM C140.
- C. Water-Vapor Transmission: Comply with one or both of the following:
1. Maximum 10 percent reduction in water-vapor transmission of treated compared to untreated specimens, in accordance with ASTM E96/E96M.
 2. Minimum 80 percent water-vapor transmission of treated compared to untreated specimens, in accordance with ASTM D1653.
- D. Water Penetration and Leakage through Masonry: Minimum 90 percent reduction in leakage rate of treated compared to untreated specimens, in accordance with ASTM E514/E514M.
- E. Durability: Maximum 5 percent loss of water-repellent performance after 2500 hours of weathering in accordance with ASTM G154 compared to water-repellent-treated specimens before weathering.
- 2.02 PENETRATING WATER REPELLENTS
- A. Penetrating Low-VOC Silane Water Repellent: Clear, containing 100 percent active content of silane; with alcohol, mineral spirits, water, or other proprietary solvent carrier; and with 400 g/L or less of VOCs.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dayton Superior Corporation.
 - b. Euclid Chemical Company (The); an RPM company.
 - c. Master Builders Solutions.
 - d. PROSOCO, Inc.
 - e. Pecora Corporation.
- B. Penetrating Low-VOC Silane/Siloxane-Blend Water Repellent: Clear, containing 10 percent or more active content of silane and siloxane blend with 400 g/L or less of VOCs.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Euclid Chemical Company (The); an RPM company.
 - b. Master Builders Solutions.
 - c. PROSOCO, Inc.

- d. Pecora Corporation.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements and conditions affecting performance of the Work.
 - 1. Verify that surfaces are clean and dry in accordance with water-repellent manufacturer's requirements. Check moisture content in three representative locations by method recommended by manufacturer.
 - 2. Verify that there is no efflorescence or other removable residues that would be trapped beneath the application of water repellent.
 - 3. Verify that required repairs are complete, cured, and dry before applying water repellent.
- B. Test pH level in accordance with water-repellent manufacturer's written instructions to ensure chemical bond to silica-containing or siliceous minerals.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. New Construction and Repairs: Allow concrete and other cementitious materials to age before application of water repellent, in accordance with repellent manufacturer's written instructions.
- B. Cleaning: Before application of water repellent, clean substrate of substances that could impair penetration or performance of product in accordance with water-repellent manufacturer's written instructions.
- C. Protect adjoining work, including mortar and sealant bond surfaces, from spillage or blow-over of water repellent. Cover adjoining and nearby surfaces of aluminum and glass if there is the possibility of water repellent being deposited on surfaces. Cover live vegetation.
- D. Coordination with Mortar Joints: Do not apply water repellent until pointing mortar for joints adjacent to surfaces receiving water-repellent treatment has been installed and cured.
- E. Coordination with Sealant Joints: Do not apply water repellent until sealants for joints adjacent to surfaces receiving water-repellent treatment have been installed and cured.

3.03 APPLICATION OF WATER REPELLENTS

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect the substrate before application of water repellent and to instruct Applicator on the product and application method to be used.
- B. Comply with manufacturer's written instructions for application procedure unless otherwise indicated.

3.04 FIELD QUALITY CONTROL

- A. Testing of Water-Repellent Material: Owner reserves the right to invoke the following procedure at any time and as often as Owner deems necessary during the period when water repellent is being applied:
 - 1. Owner will engage the services of a qualified testing agency to sample water-repellent material being used. Samples of material delivered to Project site will be taken, identified, sealed, and certified in presence of Contractor.
 - 2. Testing agency will perform tests for compliance of water-repellent material with product requirements.
 - 3. Owner may direct Contractor to stop applying water repellents if test results show material being used does not comply with product requirements. Contractor to remove noncomplying material from Project site, pay for testing, and correct deficiency of surfaces treated with rejected materials, as approved by Engineer.
- B. Coverage Test: In the presence of Engineer, hose down a dry, repellent-treated surface to verify complete and uniform product application. A change in surface color will indicate incomplete application.
 - 1. Notify Engineer seven days in advance of the dates and times when surfaces will be tested.
 - 2. Reapply water repellent until coverage test indicates complete coverage.

3.05 CLEANING

- A. Immediately clean water repellent from adjoining surfaces and surfaces soiled or damaged by water-repellent application as work progresses. Correct damage to work of other trades caused by water-repellent application, as approved by Engineer.
- B. Comply with manufacturer's written cleaning instructions.

END OF SECTION

SECTION 07 21 00
THERMAL INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Extruded polystyrene foam-plastic board insulation.
2. Glass-fiber blanket insulation.
3. Mineral-wool blanket insulation.
4. Mineral-wool board insulation.

B. Related Requirements:

1. Section 04 22 00 "Concrete Unit Masonry" for insulation installed in masonry cells.
2. Section 07 53 23 "Ethylene-Propylene-Diene-Monomer (EPDM) Roofing" for insulation specified as part of roofing construction.
3. Section 09 29 00 "Gypsum Board" for sound attenuation blanket used as acoustic insulation.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Extruded polystyrene foam-plastic board insulation.
2. Glass-fiber blanket insulation.
3. Mineral-wool blanket insulation.
4. Mineral-wool board insulation.

1.03 INFORMATIONAL SUBMITTALS

- A. Installer's Certification: Listing type, manufacturer, and R-value of insulation installed in each element of the building thermal envelope.
- B. Product Test Reports: For each product, for tests performed by a qualified testing agency.
- C. Research Reports: For foam-plastic insulation, from ICC-ES.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.
- B. Protect foam-plastic board insulation as follows:
 - 1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
 - 2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site until just before installation time.
 - 3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Maximum flame-spread and smoke-developed indexes less than 25 and 450 when tested in accordance with ASTM E84.
- B. Fire-Resistance Ratings: Comply with ASTM E119 or UL 263; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Indicate design designations from UL's "Fire Resistance Directory" or from listings of another qualified testing agency.
- C. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
- D. Thermal-Resistance Value (R-Value): R-value as indicated on Drawings in accordance with ASTM C518.

2.02 EXTRUDED POLYSTYRENE FOAM-PLASTIC BOARD INSULATION (INSUL-5)

- A. Extruded Polystyrene Board Insulation, Type IV: ASTM C578, Type IV, 25-psi (173-kPa) minimum compressive strength; unfaced.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Chemical Company (The).
 - b. DuPont.

- c. Kingspan Insulation Limited.
 - d. Owens Corning.
 - 2. Flame-Spread Index: Not more than 25 when tested in accordance with ASTM E84.
 - 3. Smoke-Developed Index: Not more than 450 when tested in accordance with ASTM E84.
 - 4. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.
 - 5. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
 - 6. Application: Vertical foundation insulation.
- B. Extruded Polystyrene Board Insulation, Type VI: ASTM C578, Type VI, 40-psi minimum compressive strength; unfaced.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Chemical Company (The).
 - b. DuPont.
 - c. Kingspan Insulation Limited.
 - d. Owens Corning.
 - 2. Flame-Spread Index: Not more than 25 when tested in accordance with ASTM E84.
 - 3. Smoke-Developed Index: Not more than 450 when tested in accordance with ASTM E84.
 - 4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
 - 5. Application: Horizontal under-slab insulation.

2.03 GLASS-FIBER BLANKET INSULATION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Certainteed; SAINT-GOBAIN.
 - 2. Johns Manville; a Berkshire Hathaway company.

3. Knauf Insulation.

4. Owens Corning.

B. Glass-Fiber Blanket Insulation, Unfaced: ASTM C665, Type I; passing ASTM E136 for combustion characteristics.

2.04 MINERAL-WOOL BLANKET INSULATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Johns Manville; a Berkshire Hathaway company.

2. Owens Corning.

3. ROCKWOOL.

B. Mineral-Wool Blanket Insulation, Unfaced: ASTM C665, Type I (blankets without membrane facing); consisting of fibers; passing ASTM E136 for combustion characteristics.

2.05 SOUND ATTENUATION FIRE BATTS (SAFB)

A. Sound attenuation batts shall be mineral wool made from inorganic fibers. SAFBs shall meet the requirements of ASTM C 665, Type I, unfaced and shall have a maximum flame spread index of zero (0) and a maximum smoke developed index of zero (0) per ASTM E 84.

B. Minimum Density shall be 2.4 pcf. R-value shall be as shown on the Contract Drawings.

C. Manufacturers:

1. Rockwool – Safe'n'Sound

2. Owens Corning – Thermafiber SAFB

3. Johns Manville – MinWool SAFB

2.06 MINERAL-WOOL BOARD INSULATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Johns Manville; a Berkshire Hathaway company.

2. Owens Corning.

3. ROCKWOOL.

- B. Mineral-Wool Board Insulation, Type IVB: ASTM C612, Type IVB; unfaced.

1. Nominal Density: 8 lb/cu. ft. (128 kg/cu. m).

2.07 INSULATION FASTENERS

- A. Adhesively Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.

1. Plate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.762 mm) thick by 2 inches (50 mm) square.
2. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation.

- B. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.

1. Angle: Formed from 0.030-inch- (0.762-mm-) thick, perforated, galvanized carbon-steel sheet with each leg 2 inches (50 mm) square.
2. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation.

- C. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized-steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) square or in diameter.

- D. Insulation Standoff: Spacer fabricated from galvanized mild-steel sheet for fitting over spindle of insulation anchor to maintain air space as dimensioned on the Drawings between face of insulation and substrate to which anchor is attached.

- E. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates without damaging insulation, fasteners, or substrates.

2.08 ACCESSORIES

- A. Insulation for Miscellaneous Voids:

1. Glass-Fiber Insulation: ASTM C764, Type II, loose fill; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E84.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Clean substrates of substances that are harmful to insulation, including removing projections capable of puncturing insulation or vapor retarders, or that interfere with insulation attachment.

3.02 INSTALLATION, GENERAL

- A. Comply with insulation manufacturer's written instructions applicable to products and applications.
- B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.
- C. Install insulation with manufacturer's R-value label exposed after insulation is installed.
- D. Extend insulation to envelop entire area to be insulated. Fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.
- E. Provide sizes to fit applications and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units unless multiple layers are otherwise shown or required to make up total thickness or to achieve R-value.

3.03 INSTALLATION OF SLAB INSULATION

- A. On vertical slab edge and foundation surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.
 - 1. If not otherwise indicated, extend insulation a minimum of 36 inches (915 mm) below exterior grade line.
- B. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.
 - 1. If not otherwise indicated, extend insulation a minimum of 24 inches (610 mm) in from exterior walls.

3.04 INSTALLATION OF FOUNDATION WALL INSULATION

- A. Butt panels together for tight fit.
- B. Anchor Installation: Install board insulation on concrete substrates by adhesively attached, spindle-type insulation anchors as follows:
 - 1. Fasten insulation anchors to concrete substrates with insulation anchor adhesive according to anchor manufacturer's written instructions.

2. Space anchors according to insulation manufacturer's written instructions for insulation type, thickness, and application.
 3. Apply insulation standoffs to each spindle to create cavity width indicated on Drawings between concrete substrate and insulation.
 4. After adhesive has dried, install board insulation by pressing insulation into position over spindles and securing it tightly in place with insulation-retaining washers, taking care not to compress insulation.
 5. Where insulation will not be covered by other building materials, apply capped washers to tips of spindles.
- C. Adhesive Installation: Install with adhesive or press into tacky waterproofing or damp proofing according to manufacturer's written instructions.

3.05 INSTALLATION OF CAVITY-WALL INSULATION

- A. Mineral-Wool Board Insulation: Install insulation fasteners 4 inches (100 mm) from each corner of board insulation, at center of board, and as recommended by manufacturer.
1. Fit courses of insulation between obstructions, with edges butted tightly in both directions, and with faces flush.
 2. Press units firmly against inside substrates.

3.06 INSTALLATION OF INSULATION IN FRAMED CONSTRUCTION

- A. Blanket Insulation: Install in cavities formed by framing members according to the following requirements:
1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
 2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
 3. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.
 4. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.
- B. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials:

1. Glass-Fiber Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).

3.07 PROTECTION

- A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes.
- B. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION

SECTION 07 27 26

FLUID-APPLIED MEMBRANE AIR BARRIERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Air barriers, vapor permeable.

1.02 DEFINITIONS

- A. Air-Barrier Accessory: A transitional component of the air barrier that provides continuity.
- B. Air-Barrier Assembly: The collection of air-barrier materials and accessories applied to an opaque wall, including joints and junctions to abutting construction, to control air movement through the wall.
- C. Air-Barrier Material: A primary element that provides a continuous barrier to the movement of air.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review air-barrier requirements and installation, special details, mockups, air-leakage and bond testing, air-barrier protection, and work scheduling that covers air barriers.

1.04 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's written instructions for evaluating, preparing, and treating each substrate; technical data; dry film thickness; and tested physical and performance properties of products.
- B. Shop Drawings: For air-barrier assemblies.
 1. Show locations and extent of air-barrier materials, accessories, and assemblies specific to Project conditions.
 2. Include details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.
 3. Include details of interfaces with other materials that form part of air barrier.

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer. Include list of ABAA-certified installers and supervisors employed by Installer, who work on Project.
- B. Product Certificates: From air-barrier manufacturer, certifying compatibility of air barriers and accessory materials with Project materials that connect to or that come in contact with the barrier.
- C. Product Test Reports: For each air-barrier assembly, for tests performed by a qualified testing agency.
- D. Field quality-control reports.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
 - 1. Installer to be licensed by ABAA in accordance with ABAA's Quality Assurance Program and to employ ABAA-certified installers and supervisors on Project.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Remove and replace liquid materials that cannot be applied within their stated shelf life.
- B. Protect stored materials from direct sunlight.

1.08 FIELD CONDITIONS

- A. Environmental Limitations: Apply air barrier within the range of ambient and substrate temperatures recommended in writing by air-barrier manufacturer.
 - 1. Protect substrates from environmental conditions that affect air-barrier performance.
 - 2. Do not apply air barrier to a damp or wet substrate or during snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain primary air-barrier materials and air-barrier accessories from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Air-Barrier Performance: Air-barrier assembly and seals with adjacent construction to be capable of performing as a continuous air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-

barrier assemblies to be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, tie-ins to installed waterproofing, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.

- B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.2 L/s x sq. m of surface area at 75 Pa), when tested in accordance with ASTM E2357.
- C. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.02 L/s x sq. m of surface area at 75 Pa) pressure difference; ASTM E2178.
- D. Ultimate Elongation: Minimum 200 percent; ASTM D412, Die C.
- E. Adhesion to Substrate: Minimum 16 lbf/sq. in. (110 kPa) when tested in accordance with ASTM D4541.
- F. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.
- G. UV Resistance: Can be exposed to sunlight for 180 days in accordance with manufacturer's written instructions.

2.03 AIR BARRIERS, VAPOR PERMEABLE

- A. Vapor-Permeable Air Barrier, Synthetic Polymer Type: Synthetic polymer membrane with an installed dry film thickness, according to manufacturer's written instructions.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. GCP Applied Technologies Inc.
 - b. Henry Company; a Carlisle company.
 - c. Tremco Incorporated.
 - d. Carlisle Coatings & Waterproofing Inc.
 - e. GE Construction Sealants; Momenite Performance Materials Inc.
 - f. Sto Corp.
 - g. Master Builders Solutions.
 - h. PROSOCO, Inc.
 - i. Soprema, Inc.

- j. The Dow Chemical Company.
- 2. Vapor Permeance: Minimum 5 perms (290 ng/Pa x s x sq. m); ASTM E96/E96M, Procedure A, Desiccant Method.

2.04 ACCESSORY MATERIALS

- A. Provide primers, transition strips, termination strips, joint reinforcing fabric and strips, joint sealants, counterflashing strips, flashing sheets and metal termination bars, termination mastic, substrate patching materials, adhesives, tapes, foam sealants, lap sealants, and other accessory materials that are recommended in writing by air-barrier manufacturer to produce a complete air-barrier assembly and that are compatible with primary air-barrier material and adjacent construction to which they may seal.
- B. Primer: Liquid waterborne primer recommended for substrate by air-barrier material manufacturer.
- C. Stainless Steel Sheet: ASTM A240/A240M, Type 304, 0.0187 inch (0.5 mm) thick, and Series 300 stainless steel fasteners.
- D. Preformed Silicone Extrusion: Manufacturer's standard system consisting of cured low-modulus silicone extrusion, sized to fit opening widths, with a single-component, neutral-curing, Class 100/50 (low-modulus) silicone sealant for bonding extrusions to substrates.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
 - 1. Verify that substrates are sound and free of oil, grease, dirt, excess mortar, or other contaminants.
 - 2. Verify that substrates have cured and aged for minimum time recommended in writing by air-barrier manufacturer.
 - 3. Verify that substrates are visibly dry and free of moisture. Test concrete substrates for capillary moisture by plastic sheet method in accordance with ASTM D4263.
 - 4. Verify that masonry joints are flush and completely filled with mortar.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 SURFACE PREPARATION

- A. Clean, prepare, treat, fill, and seal substrate and joints and cracks in substrate in accordance with manufacturer's written instructions and details. Provide clean, dust-free, and dry substrate for air-barrier application.
- B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.
- C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
- D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching material.
- E. Remove excess mortar from masonry ties, shelf angles, and other obstructions.
- F. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.
- G. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.
- H. Bridge isolation joints, expansion joints, and discontinuous wall-to-wall, deck-to-wall, and deck-to-deck joints with air-barrier accessory material that accommodates joint movement in accordance with manufacturer's written instructions and details.

3.03 INSTALLATION OF ACCESSORIES

- A. Install accessory materials in accordance with air-barrier manufacturer's written instructions and details to form a seal with adjacent construction and ensure continuity of air and water barrier.
 - 1. Coordinate the installation of air barrier with installation of roofing membrane and base flashing to ensure continuity of air barrier with roofing membrane.
 - 2. Install transition strip on roofing membrane or base flashing so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate.
 - 3. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
 - 4. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.

3.04 INSTALLATION OF PRIMARY AIR-BARRIER MATERIAL

- A. Apply air-barrier material to form a seal with strips and transition strips and to achieve a continuous air barrier in accordance with air-barrier manufacturer's written instructions and details. Apply air-barrier material within manufacturer's recommended application temperature ranges.
 - 1. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
 - 2. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.
 - 3. Where multiple prime coats are needed to achieve required bond, allow adequate drying time between coats.
- B. Do not cover air barrier until it has been tested and inspected by testing agency.
- C. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.05 FIELD QUALITY CONTROL

- A. ABAA Quality Assurance Program: Perform examinations, preparation, installation, testing, and inspections under ABAA's Quality Assurance Program.
- B. Testing Agency: Owner may engage a qualified testing agency to perform tests and inspections.
- C. Inspections: Air-barrier materials, accessories, and installation are subject to inspection for compliance with requirements. Inspections may include the following:
 - 1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.
 - 2. Air-barrier dry film thickness.
 - 3. Continuous structural support of air-barrier system has been provided.
 - 4. Masonry and concrete surfaces are smooth, clean, and free of cavities, protrusions, and mortar droppings.
 - 5. Site conditions for application temperature and dryness of substrates have been maintained.
 - 6. Maximum exposure time of materials to UV deterioration has not been exceeded.
 - 7. Surfaces have been primed, if applicable.

8. Laps in strips and transition strips have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.
 9. Termination mastic has been applied on cut edges.
 10. Strips and transition strips have been firmly adhered to substrate.
 11. Compatible materials have been used.
 12. Transitions at changes in direction and structural support at gaps have been provided.
 13. Connections between assemblies (air-barrier and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.
 14. All penetrations have been sealed.
- D. Tests: As determined by testing agency from among the following tests:
1. Air-Leakage-Volume Testing: Air-barrier assemblies will be tested for air-leakage rate in accordance with ASTM E783 or ASTM E2357.
 2. Adhesion Testing: Air-barrier assemblies will be tested for required adhesion to substrate in accordance with ASTM D4541 for each 600 sq. ft. (56 sq. m) of installed air barrier or part thereof.
- E. Air barriers will be considered defective if they do not pass tests and inspections.
1. Apply additional air-barrier material, in accordance with manufacturer's written instructions, where inspection results indicate insufficient thickness.
 2. Remove and replace deficient air-barrier components for retesting as specified above.
- F. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.
- G. Prepare test and inspection reports.

3.06 CLEANING AND PROTECTION

- A. Protect air-barrier system from damage during application and remainder of construction period, in accordance with manufacturer's written instructions.
1. Protect air barrier from exposure to UV light and harmful weather exposure as recommended in writing by manufacturer. If exposed to these conditions for longer than recommended, remove and replace air barrier or install additional, full-

thickness, air-barrier application after repairing and preparing the overexposed materials in accordance with air-barrier manufacturer's written instructions.

2. Protect air barrier from contact with incompatible materials and sealants not approved by air-barrier manufacturer.
- B. Clean spills, stains, and soiling from construction that would be exposed in the completed work using cleaning agents and procedures recommended in writing by manufacturer of affected construction.
 - C. Remove masking materials after installation.

END OF SECTION

SECTION 07 42 10.11

COMPOSITE FRAMING SUPPORT SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Composite framing support system as full girts to be used with in-fill insulation integrated with metal wall panel cladding
 - 1. Substrates include: Cold-Formed Metal Framing.
- B. Related Requirements:
 - 1. Section 07 21 00 "Thermal Insulation"
 - 2. Section 07 27 26 "Fluid-Applied Membrane Air Barriers"
 - 3. Section 07 92 00 "Joint Sealants": Perimeter sealant

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate construction of wall cladding support system over substrate indicated for proper drainage, flashing, trim, back-up support, soffits, and other related Work.
 - 1. Review and finalize construction schedule.
 - 2. Verify availability of materials, installer's personnel, equipment, and facilities needed to maintain schedule.
 - 3. Review means and methods related to installation, including manufacturer's written instructions.
 - 4. Examine support conditions for compliance with requirements, including alignment and attachment to structural support system.
 - 5. Review flashings, wall cladding details, wall penetrations, openings, and condition of other construction that affects this Work.
 - 6. Review temporary protection requirements for during and after installation of this Work.

1.03 SUBMITTALS

- A. Product Data: Submit for each type of product indicated; include construction details, material descriptions, dimensions of individual components and profiles, and accessories as necessary for complete fully functioning and assembled system.
 - 1. Continuous insulation support system attachment methods and required fasteners
 - 2. Wall-mounted items including doors, windows, louvers, and lighting fixtures
 - 3. Wall penetrations including pipes, electrical fixtures, and any other utilities
- B. Test and Inspection Reports: Submit test and inspection reports on each type of wall cladding/veneer system based on evaluation of comprehensive tests performed by nationally recognized testing agency.
- C. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with at least three years of documented experience.
- B. Installer: Company specializing in performing work of this section and the following:
 - 1. Install system in strict compliance with manufacturer's installation instructions.
 - 2. Have not less than three years of documented experience.
- C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Build integrated mockups of exterior wall assembly as described in Section 01 43 39 "Mockups."
 - a. Include typical components, corner, supports, accessories, and methods of installation.
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to site in manufacturer's original unopened containers and packaging with labels clearly identifying product name and manufacturer.

- B. Deliver components and other manufactured items or accessories without damage or deformation.
- C. Storage: Store materials in clean, dry, and level interior areas or outdoor areas for limited duration in accordance with manufacturer's written instructions.
- D. Protect components and auxiliary accessories during transportation, handling, and installation from moisture, excessive temperatures and other construction operations in accordance with manufacturer's written instructions.
- E. Handle components in strict compliance with manufacturer's written instructions and recommendations, and in a manner to prevent bending, warping, twisting, and surface, edge or corner damage.

1.06 SITE CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of this Work in accordance with manufacturer's written installation instructions and warranty requirements.

1.07 WARRANTY

- A. System Warranty: Provide written warranty by manufacturer agreeing to correct defects in manufacturing within five year period after date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Basis-of-Design: Subject to compliance with the requirements provide Advanced Architectural Products (A2P): SMARTci GreenGirt Composite Metal Hybrid Framing Support (CMH) System or comparable composite material products by:
 - 1. Armatherm Thermal Bridging Solutions.
 - 2. Strongwell Strongirt.

2.02 DESCRIPTION

- A. Attach CMH sub-framing system components to exterior sheathing over metal stud framing.
- B. Install CMH sub-framing system components horizontally on framed sheathing substrate system as indicated on drawings in compliance with specified requirements.

2.03 PERFORMANCE REQUIREMENTS

- A. Structural: Provide system tested in accordance with ASTM E330/E330M and certified to be without permanent deformation or failure of structural members in accordance with design wind velocities for project geographic location and probability of occurrence based on data from wind velocity maps provided in ASCE 7 and as approved by authorities having jurisdiction (AHJ).
1. Provide finite element analysis (FEA) to model and evaluate areas of the longest composite girt cantilever span possible between intermediate framing members/attachment.
 - a. FEA shall include max dead load and wind load conditions
 - b. FEA shall include point loads representative of fastener locations
 - c. Maximum directional stresses in model shall have a safety factor of 4 or greater.
 - d. Stresses shall be indicated and analyzed in 3 directions.
 - e. FEA shall accurately replicate the wall system and physical loading dynamics.
 - f. Report shall be furnished with the submittal.
 - g. FEA shall be approved by a licensed PE.
 2. Butt joints (non-interlocking joints) of adjacent girts shall be installed on a minimum surface width of 3-inches or double stud condition to accommodate proper fastener margins to composite.
- B. System Thermal Design: Ensure installed insulation and CMH sub-framing system, rough opening trim, and cladding attachment does not have thermal bridging of fasteners or framing that creates a continuous metal path from exterior surface of insulation to interior face of insulation.
1. System thermal design shall meet or exceed thermal design requirements in compliance with IECC or IgCC energy code.
 2. Thermal Performance Test: Provide thermal resistance (R-value) indicated, in compliance with ASTM C1363, corrected to 15 mph outside and still air inside, with installed condition including fastening and joints.
 - a. Provide efficiency of no less than 93 to 98 percent, with a maximum temperature differential of 18 degrees F from interior wall surface to interior wall cavity and node locations with a 70 degrees F exterior to interior wall temperature delta.

- b. Provide test unit with at least one insulation panel horizontal and vertical joint length and height of test chamber area.
 - c. Provide finite element analysis of three dimensional simulation of described wall assembly sealed by professional engineer in compliance with performance requirements and exceeding it by at least 3 percent.
- C. Temperature: Comply with structural loading requirements within temperature range of minus 55 degrees F to 180 degrees F.
- D. Fire-Test-Response Characteristics: Provide composite framing support system with fire-test results indicated as determined by test standard indicated and applied by UL or other testing and inspection agency acceptable to authorities having jurisdiction.
 - 1. Surface Burning Characteristics: In compliance with ASTM E84, for foam insulation, fiber reinforced polymer (FRP) and interior surfaces as follows:
 - a. Flame Spread Index (FSI): 25 or less.
 - b. Smoke Developed Index (SDI): 450 or less.
 - 2. Intermediate Scale Multistory Fire Test: Comply with NFPA 285 and/or IBC acceptance criteria for wall height above grade and fire separation distances, when wall type and other noted conditions require such testing or compliance with requirements as indicated.

2.04 COMPOSITE METAL HYBRID (CMH) SUB-FRAMING SYSTEM

- A. CMH System: Provide CMH system consisting of polyester resin matrix with recycled materials, fire retardant additives and reinforced with integral continuous metal inserts the length of profile at all fastening locations. Reinforce CMH sub-framing systems with glass strand rovings used internally for longitudinal (lengthwise) strength and continuous strand glass mats or stitched reinforcements used internally for transverse (crosswise) strength.
 - 1. Depth of Girt: Refer to Drawings.
 - 2. On Center Spacing: Refer to Drawings.
 - 3. Provide continuous non-corrosive steel insert for engagement of fasteners, at least 16 gauge thick with G90 galvanized coating designation in compliance with ASTM A653/A653M.
 - a. Fully engage and secure steel insert with adjacent CMH at ends, allowing for thermal expansion.
 - b. Anchor sub-girts and other wall cladding support accessories to steel insert set into and part of CMH.

4. Provide integral compression seal in CMH sections to ensure insulation panel will not dislodge.
5. Provide integral anti-siphon grooves on exterior and interior flanges of CMH.
6. Provide force distribution zones integrally designed into profile of CMH.
7. Surface Burning Characteristics:
 - a. Flame Spread Index (FSI): 25 or less, when tested in accordance with ASTM E84.
 - b. Smoke Developed Index (SDI): 450 or less, when tested in accordance with ASTM E84.
8. Self-Extinguishing: Comply with ASTM D635.
9. Profile Visual Requirements: Per ASTM D4385.

2.05 ACCESSORIES

- A. Provide accessories necessary for complete sub-framing system including closure trim, transition angles, tie-in brackets, and similar items.
- B. Composite Trim: Provide nonstructural composite trim at rough openings to properly transition CI system.
 1. Use trim angles and accessories sized to enclose CI system to provide thermally broken transition from opaque wall assemblies.
 2. Use sealant and tapes as required to transition vapor barrier from substrate onto trim.
 3. Trim to provide 90 degree transition of continuous insulated substrate for vapor barrier and exterior flashings.
 4. Trim to be covered by exterior panel construction and flashings.
- C. Horizontal Hat Channels: 16 gauge or 18 gauge minimum thickness, hot dipped galvanized with standard G90 coating designation in compliance with ASTM A653/A653M.
- D. Fasteners: Corrosion-resistant, self-tapping and self-drilling screws, bolts, nuts, and other fasteners as recommended by sub-framing manufacturer for project application.
 1. Cladding to CMH: Use standard self-tapping metal screws.
 2. CMH to Metal Stud Wall Framing: Use standard self-tapping metal screws.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas of this work, and project conditions with installer present for compliance with requirements for installation tolerances, substrates, sub-framing system conditions, and other conditions affecting performance of this Work.
- B. Examine structural wall framing to ensure that angles, channels, studs, and other structural support members have been installed within alignment tolerances required by sub-framing system manufacturer.
- C. Examine rough-in for components and systems penetrating sub-framing system to coordinate actual locations of penetrations relative to sub-framing systems joint locations prior to installation.
- D. Verify that mechanical and electrical services for exterior walls have been installed and tested and, if appropriate, verify that adjacent materials and finishes are dry and ready to receive insulation.
- E. Proceed with installation only after wall substrate surfaces have been properly prepared and unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using methods recommended by sub-framing system manufacturer for achieving best result for substrate under project conditions.
- C. Prepare sub-framing, base angles, sills, furring, and other sub-framing system members and provide anchorage in accordance with ASTM C754 for substrate type and wall cladding type in accordance with manufacturer's installation instructions.

3.03 INSTALLATION

- A. Install sub-framing system in accordance with manufacturer's installation instructions.
- B. Install sub-framing system in compliance with system orientation, sizes, and locations as indicated on drawings.

3.04 TOLERANCES

- A. Shim and align sub-framing system within installed tolerances of 1/4 inch in 20 feet, non-cumulative, level, plumb, and on location lines as indicated.

3.05 PROTECTION

- A. Protect installed products from damage until Date of Substantial Completion.

B. Replace damaged insulation prior to Date of Substantial Completion.

END OF SECTION

SECTION 07 42 13.16

MODULAR METAL WALL PANELS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes concealed fastener, coil coated, rainscreen wall panel as part of the wall assemblies, including matching copings and roof-edge drainage systems.

1.02 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Meet with Owner, Engineer, Owner's insurer if applicable, metal panel Installer, metal panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal panels, including installers of doors, windows, and louvers.
 - 2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 3. Review methods and procedures related to metal panel installation, including manufacturer's written instructions.
 - 4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
 - 5. Review flashings, special siding details, wall penetrations, openings, and condition of other construction that affect metal panels.
 - 6. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
 - 7. Review temporary protection requirements for metal panel assembly during and after installation.
 - 8. Review procedures for repair of metal panels damaged after installation.
 - 9. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment assembly, trim, flashings, closures, and accessories; and special details.
2. Accessories: Include details of the flashing, trim, and anchorage, at a scale of not less than 1-1/2 inches per 12 inches (1:10).

C. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.

1. Metal Panels: 12 inches (305 mm) long by actual panel width. Include fasteners, closures, and other metal panel accessories.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Manufacturer and Installer.

B. Product Test Reports: For each product, tests performed by a qualified testing agency.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Approved manufacturer listed in this Section with minimum 10 years' experience in manufacture of similar products in successful use in similar applications.

1. Approval of Comparable Products: Submit the following in accordance with project substitution requirements, within time allowed for substitution review:
 - a. Product data, including certified independent test data indicating compliance with requirements.
 - b. Samples of each component.

- c. Sample submittal from similar project.
 - d. Project references: Minimum of 5 installations not less than 5 years old, with Owner and Engineer contact information.
 - e. Sample warranty.
 - 2. Substitutions following award of contract are not allowed except as stipulated in Division 01 General Requirements.
 - 3. Approved manufacturers must meet separate requirements of Submittals Article.
 - B. Wall Systems Installer Qualifications: Experienced Installer with minimum of 5 years' experience with successfully completed projects of a similar nature and scope.
 - C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - 1. Build mockup of typical metal panel assembly as shown on Drawings, including supports, attachments, and accessories. Refer to Section 01 43 39 "Mockups."
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.
- 1.07 DELIVERY, STORAGE, AND HANDLING
- A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.
 - B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.
 - C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.
 - D. Retain strippable protective covering on metal panels during installation.
- 1.08 FIELD CONDITIONS
- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.09 COORDINATION

- A. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

- 1. Failures include, but are not limited to, the following:

- a. Structural failures including rupturing, cracking, or puncturing.
 - b. Deterioration of metals and other materials beyond normal weathering.

- 2. Warranty Period: Ten years from date of Substantial Completion.

- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

- 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

- a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

- 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E330:

- 1. Wind Loads: As indicated on Drawings.
 - 2. Other Design Loads: As indicated on Drawings.

- B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of

components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.02 METAL PANEL WALL SYSTEM ASSEMBLY

- A. Modular metal wall panel system consisting of aluminum panels in a rainscreen application as part of the assembly described below.
- B. Modular Metal Wall Panels over Multi-Component Framed Wall Systems:
 1. Modular metal wall panels applied as exterior rainscreen cladding over wall framing specified in Division 05 Section "Cold-Formed Metal Framing" with exterior sheathing specified in Division 06 Section "Sheathing", an applied membrane that provides air, moisture, and water vapor control specified in Division 07 Section "Air Barriers," insulation within the framing specified in Division 07 Section "Thermal Insulation," and composite framing support system specified in Division 07 section "Composite Framing Support System." Metal wall panel installation specified in this Section includes mounting clips for panel attachment.
 2. Modular metal wall panels applied as exterior rainscreen cladding over CMU specified in Division 04 Section "Concrete Unit Masonry" with an applied membrane that provides air, moisture, and water vapor control specified in Division 07 Section "Air Barriers." Metal wall panel installation specified in this Section includes secondary metal subgirt framing and mounting clips for panel attachment.

2.03 METAL WALL PANELS

- A. Metal Wall Panels: Provide factory-formed, metal wall panels fabricated from single sheets of metal formed into profile for installation method indicated. Include attachment assembly components, and accessories required for a complete system.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide East Coast Metal Systems EC-300 System or comparable product by one of the following:
 - a. ATAS Omawall.
 - b. Pac-Clad Modular AL
- B. Modular Metal Panels: Factory-formed, aluminum-faced panels fabricated from 0.63" thick aluminum coil coated sheet.
 1. Panel Depth: 1-3/8"(35mm).

2. Panel Flatness: Maximum allowable distortion: 1/32 inch in 24 inches (0.813 mm in 610 mm) in any direction. Panel lines, breaks, and angles shall be sharp and true, and surfaces shall be free from warp or buckle.
 3. Clips: Manufacturer's standard clips as required to meet performance requirements.
 4. Panel Joints: 3/4"(19mm) or as indicated on drawings.
 5. Panel Sizes: As indicated on drawings.
 6. Sheet Surface: Smooth.
- C. Aluminum Sheet: Smooth surface coil-coated sheet, ASTM B209, 3105-H14 Alloy.
1. Aluminum Material: Tension-leveled
 2. Thickness: 0.063" nominal
 3. Weight: Approximately 1.5 lb. per square foot
- D. Aluminum Face Sheet Finish: Refer to Drawings for all finish locations and colors.
1. Unexposed Finish: Manufacturer's standard nominal 0.5 mil nominal DFT backer coating.

2.04 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C645, cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 (Z275 hot-dip galvanized) coating designation or ASTM A792/A792M, Class AZ50 (Class AZM150) aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide manufacturer's factory-formed clips, shims, flashings, sealants, and tapes for a complete installation. Match material and finish of metal panels unless otherwise indicated.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.
1. Provide all metal copings: Manufactured coping system consisting of metal coping cap in section lengths not exceeding 12 feet (3.6 m), concealed anchorage; with corner units, end cap units, and concealed splice plates with finish matching coping caps. Finish to match metal panels.

2.05 FABRICATION

- A. General: Fabricate modular metal panels and accessories at factory identical to tested units using manufacturer's standard procedures and processes necessary to meet performance requirements.
 - 1. Provide components of modular metal panel system that are products of one manufacturer, including modular metal panels, head and sill trim, bottom weep, starter flash, and metal copings.
- B. Modular Metal Panels: Fabricate modular metal panels requiring no further fabrication or modification in field.
 - 1. Horizontal Joints: Dry seal, drained and back ventilated.
 - 2. Vertical Joints: Pre-formed returns
 - 3. Reveals: 3/4 inches (19mm)
 - 4. Standard System Depth: 1-3/8 inches (35mm)

2.06 FINISHES

- A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- C. Aluminum Panels and Accessories:
 - 1. Fluoropolymer Two-Coat System: 0.2-mil primer with 0.8-mil 70 percent PVDF fluoropolymer color coat, AAMA 620.
 - 2. Fluoropolymer Two-Coat Mica System: 0.2-mil primer with 0.8-mil 70 percent PVDF fluoropolymer color coat providing a pearlescent appearance, AAMA 620.
 - 3. Fluoropolymer Three Coat System: 0.65 mil color base coat and Primer with a 0.05 mil PVDF ink coat and a 0.45 nominal PVDF fluoropolymer clear coat.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.
 - 1. Examine wall framing to verify that girts, angles, channels, studs, and other structural panel support members and anchorage have been installed within alignment tolerances required by metal wall panel manufacturer.
 - 2. Examine wall sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal wall panel manufacturer.
 - a. Verify that air- or water-resistive barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
- B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.

3.03 INSTALLATION

- A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - 1. Shim or otherwise plumb substrates receiving metal panels.
 - 2. Attach panels to metal sub-framing using manufacturer's recommended clips, screws, fasteners, sealants, and adhesives.
 - 3. Horizontal Joinery: Working from base of installation to top, connect upper panel to lower panel at joinery.
 - 4. Vertical Joinery: Provide reveal between vertical ends of panels as shown on shop drawings.

5. Galvanic Action: Where elements of modular metal wall system will come into contact with dissimilar materials, treat faces and edges in contact with dissimilar materials as recommended by manufacturer.
 6. Install flashing and trim as metal panel work proceeds.
- B. Rainscreen Installation: Proceed with installation of manufacturer's dry seal horizontal joinery. Keep open spaces in horizontal joinery intended to ventilate cavity behind system.
- 3.04 FIELD QUALITY CONTROL
- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect completed metal wall panel installation, including accessories.
 - B. Remove and replace metal wall panels where inspections indicate that they do not comply with specified requirements.
 - C. Additional inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.
 - D. Prepare inspection reports.
- 3.05 CLEANING AND PROTECTION
- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.
 - B. After metal panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.
 - C. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 53 23

ETHYLENE-PROPYLENE-DIENE-MONOMER (EPDM) ROOFING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Ethylene-propylene-diene-monomer (EPDM) roofing.
2. Accessory roofing materials.
3. Roof insulation.
4. Insulation accessories and cover board.
5. Walkways.
6. Expansion Joints.

B. Related Requirements:

1. Section 06 10 00 "Rough Carpentry for wood nailers, curbs, and blocking.
2. Section 07 21 00 "Thermal Insulation" for insulation beneath the roof deck.
3. Section 07 62 00 "Sheet Metal Flashing and Trim" for metal roof flashings and counterflashings.
4. Section 07 92 00 "Joint Sealants" for joint sealants, joint fillers, and joint preparation.
5. Section 22 14 23 "Storm Drainage Piping Specialties" for roof drains.

1.02 DEFINITIONS

- ###### A. Roofing Terminology: Definitions in ASTM D1079 and glossary of NRCA's "The NRCA Roofing Manual: Membrane Roof Systems" apply to work of this Section.

1.03 PREINSTALLATION MEETINGS

- ###### A. Preliminary Roofing Conference: Before starting roof deck construction, conduct conference at Project site.
1. Meet with Owner, Engineer, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's

- representative, deck Installer, air barrier Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
 3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 4. Review deck substrate requirements for conditions and finishes, including flatness and fastening.
 5. Review structural loading limitations of roof deck during and after roofing.
 6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
 7. Review governing regulations and requirements for insurance and certificates if applicable.
 8. Review temporary protection requirements for roofing system during and after installation.
 9. Review roof observation and repair procedures after roofing installation.

B. Preinstallation Roofing Conference: Conduct conference at Project site.

1. Meet with Owner, Engineer, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, air barrier Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.

7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

1.04 ACTION SUBMITTALS

A. Product Data:

1. Ethylene-propylene-diene-monomer (EPDM) roofing.
2. Accessory roofing materials.
3. Roof insulation.
4. Insulation accessories and cover board.
5. Walkways.

B. Product Data Submittals:

1. For insulation and roof system component fasteners, include copy of FM Approvals' RoofNav listing.

C. Shop Drawings: Include roof plans, sections, details, and attachments to other work, including the following:

1. Layout and thickness of insulation.
2. Base flashings and membrane terminations.
3. Flashing details at penetrations.
4. Tapered insulation, thickness, and slopes.
5. Roof plan showing orientation of steel roof deck and orientation of roof membrane and fastening spacings and patterns for mechanically fastened roofing system.
6. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
7. Tie-in with air barrier.

D. Wind Uplift Resistance Submittal: For roofing system, indicating compliance with wind uplift performance requirements.

- E. FM Global Review: Submit product data sheets, shop drawings, details, fastening information, and RoofNav Assembly Contractor's package to FM Global for review and acceptance before ordering materials and starting installation.
 - 1. Determine recommended FM Approvals wind uplift ratings for roof assemblies per RoofNav Ratings Calculator application at www.roofnav.com. Do not use any system beyond its FM Approval rating. Select assemblies based on the required wind rating for the specific roof area.
 - 2. Use assemblies listed in the online database RoofNav with an FM Global windstorm classification of 1A-90.
 - 3. Install additional securement in Zone 2 and Zone 3 per Data Sheet 1-29, Roof Deck Securement for Above-Deck Roof Components, and the roof system's Approval listing.
 - 4. Submit shop drawings and details, product data sheets, fastening specifications and a RoofNav Contractor Package to FM Global for review prior to ordering materials.
 - 5. Complete and submit the attached "Checklist for Roofing System"

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and manufacturer.
- B. Manufacturer Certificates:
 - 1. Performance Requirement Certificate: Signed by roof membrane manufacturer, certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of complying with performance requirements.
 - 2. Special Warranty Certificate: Signed by roof membrane manufacturer, certifying that all materials supplied under this Section are acceptable for special warranty.
- C. Product Test Reports: For components of roof membrane and insulation, for tests performed by a qualified testing agency, indicating compliance with specified requirements.
- D. Evaluation Reports: For components of roofing system, from ICC-ES.
 - 1. Field Test Reports:
 - 2. Fastener-pullout test results and manufacturer's revised requirements for fastener patterns.
- E. Field quality-control reports.

- F. Sample Warranties: For manufacturer's special warranties.
- 1.06 CLOSEOUT SUBMITTALS
- A. Maintenance Data: For roofing system to include in maintenance manuals.
- 1.07 QUALITY ASSURANCE
- A. Manufacturer Qualifications: A qualified manufacturer that is listed in FM Approvals' RoofNav for roofing system identical to that used for this Project.
 - B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
- 1.08 DELIVERY, STORAGE, AND HANDLING
- A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
 - B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - 1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
 - C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
 - D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.
- 1.09 FIELD CONDITIONS
- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed in accordance with manufacturer's written instructions and warranty requirements.
- 1.10 WARRANTY
- A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes roof membrane, base flashings, roof insulation, fasteners, cover boards, and other components of roofing system.
 2. Warranty Period: 30 years from Date of Substantial Completion.
- B. Special Project Warranty: Submit roofing Installer's warranty, signed by Installer, covering the Work of this Section, including all components of roofing system such as roof membrane, base flashing, roof insulation, fasteners, cover boards, and walkway products, for the following warranty period:
1. Warranty Period: Two years from Date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. General Performance: Installed roofing system and base flashings to withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing and flashings to remain watertight.
1. Accelerated Weathering: Roof membrane to withstand 2000 hours of exposure when tested in accordance with ASTM G152, ASTM G154, or ASTM G155.
 2. Impact Resistance: Roof membrane to resist impact damage when tested in accordance with ASTM D3746, ASTM D4272, or the "Resistance to Foot Traffic Test" in FM Approvals 4470.
- B. Material Compatibility: Roofing materials to be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roof membrane manufacturer based on testing and field experience.
- C. Wind Uplift Resistance: Design roofing system to resist the following wind uplift pressures when tested in accordance with FM Approvals 4474, UL 580, or UL 1897:
1. Water Treatment Facility (Upper Roof):
 - a. Zone 1 (Roof Area Field): 43 lbf/sq. ft. (2.1 kPa).
 - b. Zone 2 (Roof Area Perimeter): 57 lbf/sq. ft. (2.7 kPa).
 - c. Zone 3 (Roof Area Corners): 57 lbf/sq. ft. (2.7 kPa).
 2. Water Treatment Facility (Lower Roof):
 - a. Zone 1 (Roof Area Field): 40 lbf/sq. ft. (1.9 kPa).
 - b. Zone 2 (Roof Area Perimeter): 53 lbf/sq. ft. (2.5 kPa).

- c. Zone 3 (Roof Area Corners): 53 lbf/sq. ft. (2.5 kPa).
 - 3. Pump Station:
 - a. Zone 1 (Roof Area Field): 37 lbf/sq. ft. (1.8 kPa).
 - b. Zone 2 (Roof Area Perimeter): 48 lbf/sq. ft. (2.3 kPa).
 - c. Zone 3 (Roof Area Corners): 66 lbf/sq. ft. (3.2 kPa).
 - 4. Install additional securement in Zone 2 and Zone 3 per FM Global Data Sheet 1-2, Roof Deck Securement for Above-Deck Roof Components, and the roof system's Approval Listing.
 - D. FM Approvals' RoofNav Listing: Roof membrane, base flashings, and component materials comply with requirements in FM Approvals 4450 or FM Approvals 4470 as part of a roofing system, and are listed in FM Approvals' RoofNav for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals Certification markings.
 - 1. Fire/Windstorm Classification:
 - a. Water Treatment Facility: Class 1A-90.
 - b. Pump Station: Class 1A-75.
 - 2. Hail-Resistance Rating: FM Global Property Loss Prevention Data Sheet 1-34 MH.
 - E. Exterior Fire-Test Exposure: ASTM E108 or UL 790, Class A; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
- 2.02 ETHYLENE-PROPYLENE-DIENE-MONOMER (EPDM) ROOFING
- A. EPDM Sheet: ASTM D4637/D4637M, Type I, nonreinforced, EPDM sheet.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Johns Manville; a Berkshire Hathaway company; EPDM NR or a comparable product by one of the following:
 - a. Carlisle Syntec Systems.
 - b. Firestone Building Products.
 - c. GenFlex Roofing Systems.
 - 2. Thickness: 90 mils (2.2 mm), nominal.
 - 3. Exposed Face Color: Black.

4. Source Limitations: Obtain components for roofing system from roof membrane manufacturer or manufacturers approved by roof membrane manufacturer.

2.03 ACCESSORY ROOFING MATERIALS

- A. General: Accessory materials recommended by roofing system manufacturer for intended use and compatible with other roofing components.
 1. Adhesive and Sealants: Comply with VOC limits of authorities having jurisdiction.
- B. Sheet Flashing: 60-mil- (1.5-mm-) thick EPDM, partially cured or cured, according to application.
- C. Prefabricated Pipe Flashings: As recommended by roof membrane manufacturer.
- D. Roof Vents: As recommended by roof membrane manufacturer.
 1. Size: Not less than 4-inch (100-mm) diameter.
- E. Bonding Adhesive: Manufacturer's standard, water based.
- F. Seaming Material: Manufacturer's standard.
- G. Lap Sealant: Manufacturer's standard, single-component sealant, colored to match membrane roofing.
- H. Water Cutoff Mastic: Manufacturer's standard butyl mastic sealant.
- I. Metal Termination Bars: Manufacturer's standard, predrilled stainless steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.
- J. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening components to substrate, and acceptable to roofing system manufacturer.
- K. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, molded pipe boot flashings, preformed inside and outside corner sheet flashings, reinforced EPDM securement strips, T-joint covers, in-seam sealants, termination reglets, cover strips, and other accessories.
 1. Provide white flashing accessories for white EPDM membrane roofing.

2.04 ROOF INSULATION

- A. General: Preformed roof insulation boards manufactured or approved by EPDM roof membrane manufacturer, approved for use in FM Approvals' RoofNav-listed roof assemblies.

- B. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 1 felt facer on both major surfaces.
 - 1. Compressive Strength: 20 psi (138 kPa).
 - 2. Size: 48 by 48 inches (1219 by 1219 mm).
 - 3. Thickness: As required to meet indicated R-value, minimum 2-inches.
- C. Tapered Insulation: Provide factory-tapered insulation boards.
 - 1. Material: Match roof insulation.
 - 2. Minimum Thickness: 1/4 inch (6.35 mm).
 - 3. Slope:
 - a. Roof Field: 1/4 inch per foot (1:48) unless otherwise indicated on Drawings.
 - b. Saddles and Crickets: 1/2 inch per foot (1:24) unless otherwise indicated on Drawings.

2.05 INSULATION ACCESSORIES AND COVER BOARD

- A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with other roofing system components.
- B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.
- C. Glass-Mat Gypsum Cover Board: ASTM C1177/C1177M, water-resistant gypsum substrate.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Certainteed; SAINT-GOBAIN.
 - b. Gold Bond Building Products, LLC provided by National Gypsum Company.
 - c. USG Corporation.
 - 2. Thickness: 1/2 inch (13 mm), unless otherwise indicated.
 - 3. Surface Finish: Factory primed.

2.06 WALKWAYS

- A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway pads or rolls, approximately 3/16 inch (5 mm) thick and acceptable to roofing system manufacturer.
 - 1. Size: Approximately 36 by 60 inches (914 by 1524 mm).
 - 2. Color: Contrasting with roof membrane.

2.07 EDGE METAL COMPONENTS

- A. Expansion Joints: Provide factory fabricated weatherproof, exterior covers for expansion joint openings consisting of flexible rubber membrane, supported by a closed cell foam to form flexible bellows, with two metal flanges, adhesively and mechanically combined to the bellows by a bifurcation process. Provide product from EPDM Roofing membrane manufacturer.
 - 1. Basis of design: Johns Manville Expand-O-Flash
 - 2. Fill the space between nailers in roof expansion joints with noncombustible, compressible insulation such as glass, mineral, or ceramic fiber type.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
 - 1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
 - 2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - 3. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Section 05 31 00 "Steel Decking."
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing system installation in accordance with roofing system manufacturer's written instructions. Remove sharp projections.

- B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
- C. Perform fastener-pullout tests in accordance with roof system manufacturer's written instructions.
 - 1. Submit test result within 24 hours of performing tests.
 - a. Include manufacturer's requirements for any revision to previously submitted fastener patterns required to achieve specified wind uplift requirements.

3.03 INSTALLATION OF ROOFING, GENERAL

- A. Install roofing system in accordance with roofing system manufacturer's written instructions, FM Approvals' RoofNav assembly requirements, and FM Global Property Loss Prevention Data Sheet 1-29.
- B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at end of workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.
- C. Coordinate installation and transition of roofing system component serving as an air barrier with air barrier specified under Section 07 27 26 "Fluid-Applied Membrane Air Barriers."

3.04 INSTALLATION OF INSULATION

- A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at end of workday.
- B. Comply with roofing system and insulation manufacturer's written instructions for installing roof insulation.
- C. Installation Over Metal Decking:
 - 1. Install base layer of insulation with joints staggered not less than 24 inches (610 mm) in adjacent rows.
 - a. Locate end joints over crests of decking.
 - b. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - c. Make joints between adjacent insulation boards not more than 1/4 inch (6 mm) in width.

- d. At internal roof drains, slope insulation to create a square drain sump with each side equal to the diameter of the drain bowl plus 24 inches (610 mm).
 - (1) Trim insulation so that water flow is unrestricted.
 - e. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - f. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
 - g. Mechanically attach base layer of insulation using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to metal decks.
 - (1) Fasten insulation in accordance with requirements in FM Approvals' RoofNav for specified Windstorm Resistance Classification.
 - (2) Fasten insulation to resist specified uplift pressure at corners, perimeter, and field of roof.
2. Install upper layers of insulation and tapered insulation with joints of each layer offset not less than 12 inches (305 mm) from previous layer of insulation.
- a. Staggered end joints within each layer not less than 24 inches (610 mm) in adjacent rows.
 - b. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - c. Make joints between adjacent insulation boards not more than 1/4 inch (6 mm) in width.
 - d. At internal roof drains, slope insulation to create a square drain sump with each side equal to the diameter of the drain bowl plus 24 inches (610 mm).
 - e. Trim insulation so that water flow is unrestricted.
 - f. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
 - g. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
 - h. Loosely lay each layer of insulation units over substrate.
 - i. Attach each layer of insulation to substrate in accordance with FM Approvals' RoofNav listed roof assembly requirements for specified Windstorm Resistance Classification and FM Global Property Loss Prevention Data Sheet 1-29.

3.05 INSTALLATION OF COVER BOARDS

- A. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction.
 - 1. Trim cover board neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - 2. At internal roof drains, conform to slope of drain sump.
 - a. Trim cover board so that water flow is unrestricted.
 - 3. Cut and fit cover board tight to nailers, projections, and penetrations.
 - 4. Loosely lay cover board over substrate.
 - 5. Adhere cover board to substrate using adhesive in accordance with FM Approvals' RoofNav listed roof assembly requirements for specified Windstorm Resistance Classification, FM Global Property Loss Prevention Data Sheet 1-29, and manufacturer's written requirements.
- B. Install slip sheet over cover board and immediately beneath roofing.

3.06 INSTALLATION OF ADHERED ROOF MEMBRANE

- A. Adhere roof membrane over area to receive roofing in accordance with roofing system manufacturer's written instructions.
- B. Unroll membrane roof membrane and allow to relax before installing.
- C. Start installation of roofing in presence of roofing system manufacturer's technical personnel.
- D. Accurately align roof membrane, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.
- E. In addition to adhering, mechanically fasten roof membrane securely at terminations, penetrations, and perimeters.
- F. Apply roof membrane with side laps shingled with slope of roof deck where possible.
- G. Repair tears, voids, and lapped seams in roof membrane that do not comply with requirements.

3.07 INSTALLATION OF BASE FLASHING

- A. Install sheet flashings and preformed flashing accessories, and adhere to substrates in accordance with roofing system manufacturer's written instructions.

- B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.
- C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
- D. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.
- E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.08 INSTALLATION OF WALKWAYS

- A. Flexible Walkways: Install walkway products in accordance with manufacturer's written instructions.
 - 1. Install flexible walkways at the following locations:
 - a. Perimeter of each rooftop unit.
 - b. Between each rooftop unit location, creating a continuous path connecting rooftop unit locations.
 - c. Between each roof hatch and each rooftop unit location or path connecting rooftop unit locations.
 - d. Top and bottom of each roof access ladder.
 - e. Between each roof access ladder and each rooftop unit location or path connecting rooftop unit locations.
 - f. Locations indicated on Drawings.
 - g. As required by roof membrane manufacturer's warranty requirements.
 - 2. Provide 6-inch (76-mm) clearance between adjoining pads.
 - 3. Adhere walkway products to substrate with compatible adhesive in accordance with roofing system manufacturer's written instructions.

3.09 FIELD QUALITY CONTROL

- A. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion, in presence of Engineer, and to prepare inspection report.

- B. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.
- C. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.10 PROTECTING AND CLEANING

- A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing system, inspect roofing system for deterioration and damage, describing its nature and extent in a written report, with copies to Engineer and Owner.
- B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and in accordance with warranty requirements.
- C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

CHECKLIST FOR ROOFING SYSTEM

FM Global Clients: submit completed form and completed RoofNav Contractor Package to local FM Global field office for review.

CONTACT INFORMATION:

FM GLOBAL INDEX NUMBER:

ROOFING CONTRACTOR (NAME, ADDRESS, PROJECT NO.)	TELEPHONE NO.:	CONTACT:
	E-MAIL ADDRESS:	FAX:
CLIENT SITE (NAME & ADDRESS)	TELEPHONE NO.:	CONTACT:
	E-MAIL ADDRESS:	FAX:

OVERVIEW OF WORK: (Submit 1 form per roof area)

Building Name & Number (provide building diagram as appropriate):			
Type of Work: <input type="checkbox"/> New Construction <input type="checkbox"/> Recover (New roof over existing Roofing System) <input type="checkbox"/> Reroof (New cover/remove existing roofing system to deck) <input type="checkbox"/> Other (describe)			
Building Dimensions: Length:	ft/m;	Width:	ft/m.; Height ft/m.
Roof Slope: in. per ft. / degrees			
Parapet Height, max (in./m):		Parapet Height, min (in./m): (enter "0" if not always present)	
Roof Zone Width/Dimension*: Zone 1': Zone 1: Zone 2: Zone 3:			
FM Approved RoofNav Assembly Numbers (provide Assembly Number for individual roof zones as appropriate):			

*Refer to FM Global Property Loss Prevention Data Sheet 1-28, *Wind Design* or RoofNav for determination of various zone dimensions.

ROOF SURFACING:

<input type="checkbox"/> None			
<input type="checkbox"/> Coating (Trade Name/Application Rate)			
<input type="checkbox"/> Granules (Application Rate)			
<input type="checkbox"/> Gravel/Slag (Application Rate)			
<input type="checkbox"/> Ballast: <input type="checkbox"/> Stone Size <input type="checkbox"/> Pavers (Beveled, strapped or square edge); <input type="checkbox"/> Other:			
Ballast Weight (psf): Zone 1': Zone 1: Zone 2: Zone 3:			
Additional Detail:			

ROOF COVER / MEMBRANE:

(Provide ALL applicable details including trade name, type, number of plies, thickness, reinforced, adhesive, etc.)

Roof Cover: Trade Name:			
Hail Rating Provided:			
<input type="checkbox"/> Single Ply: <input type="checkbox"/> Reinforced <input type="checkbox"/> Unreinforced <input type="checkbox"/> Adhered <input type="checkbox"/> Fastened <input type="checkbox"/> Ballasted			
<input type="checkbox"/> Multi-Ply <input type="checkbox"/> Built Up Roofing (BUR) <input type="checkbox"/> Modified Bitumen			
Number of Plies:			
<input type="checkbox"/> Lap Width in/mm <input type="checkbox"/> Lap Adhesion Type			
<input type="checkbox"/> Panel: <input type="checkbox"/> Through Fastened Metal <input type="checkbox"/> Standing Seam metal <input type="checkbox"/> Steel <input type="checkbox"/> Aluminum <input type="checkbox"/> Copper Thickness:			
Rib Spacing: Clip Model: <input type="checkbox"/> 1- Piece <input type="checkbox"/> 2-Piece			
<input type="checkbox"/> Insulated Metal Panel Roof: Bottom facer: Metal type: Thickness			
Top facer: Material: Thickness:			
<input type="checkbox"/> Fiber Reinforced Plastic (FRP)			
<input type="checkbox"/> Other:			
<input type="checkbox"/> Spray Applied		<input type="checkbox"/> Other:	
Additional Detail:			
<input type="checkbox"/> Asphalt Shingles <input type="checkbox"/> Metal Shingles: Manufacturer: Model: <input type="checkbox"/> Ring Shank Nails			
<input type="checkbox"/> Smooth Shank Nails <input type="checkbox"/> Screws Size Number per shingle:			
<input type="checkbox"/> Concrete Tile <input type="checkbox"/> Clay Tile: Manufacturer: Model: <input type="checkbox"/> Ring Shank Nails			
<input type="checkbox"/> Smooth Shank Nails <input type="checkbox"/> Screws Size Number <input type="checkbox"/> Mortar or urethane at lower end of tile			
<input type="checkbox"/> Only mortar or urethane adhesive at top and bottom (No fasteners)			
<input type="checkbox"/> Slate tile: Width: Thickness Length of reveal: <input type="checkbox"/> Ring Shanks Nails <input type="checkbox"/> Smooth Shank Nails			
Number per tile:			
<input type="checkbox"/> Self-Adhering modified bitumen underlayment Trade Name:			

CHECKLIST FOR ROOFING SYSTEM

ROOF COVER / MEMBRANE SECUREMENT:

Roof Cover Fasteners: Trade Name:	Length:	Diameter/No.:
Stress Plate/Batten: Trade Name:	Size:	
Row Spacing: Zone 1':	Zone 1:	Zone 2: Zone 3:
Fastener Spacing: Zone 1':	Zone 1:	Zone 2: Zone 3:
Bonding Adhesive: Trade Name:		
Adhesive Ribbon Width (in.):		
Adhesive Ribbon Spacing (in.): Zone 1':	Zone 1:	Zone 2: Zone 3:
Adhesive Application Rate (gal./sq.):		
Additional Detail:		

See DS 1-49 for additional securement for all ballasted, or mechanically fastened or ribbon adhered roof covers if the roof cover is not secured within 12 in. (300 mm) of the outside edge of the nailer.

INSULATION / COVER BOARD:

Layer	Insulation / Cover Board Trade Name	Board Dimensions (ft. x. ft.)	Thickness (in.)	Fastened	Adhered	Tapered
1. Top		X		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Next		X		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Next		X		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Next		X		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Thermal Barrier		X		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Glass Fiber/Mineral Wool/Batt <input type="checkbox"/> Facer Type/Vapor Barrier						
<input type="checkbox"/> Other:						
<input type="checkbox"/> None						
Additional Detail:						

INSULATION / COVER BOARD SECUREMENT:

Insulation / Cover Board Fasteners: Trade Name:	Type:	Size:
Stress Plate: Trade Name:	Size:	
Fastener Spacing: Zone 1':	Zone 1:	Zone 2: Zone 3:
Bonding Adhesive: Trade Name:		
Adhesive Ribbon Width (in.):		
Adhesive Ribbon Spacing (in.): Zone 1':	Zone 1:	Zone 2: Zone 3:
Adhesive Application Rate (gal./sq.):		
Additional Detail:		

BASE SHEET: (Include Trade Name, Type, and Width)

<input type="checkbox"/> None	
Trade Name:	Width: <input type="checkbox"/> 36 in. <input type="checkbox"/> 1 meter (39 in.)
<input type="checkbox"/> Fastened	<input type="checkbox"/> Adhered
<input type="checkbox"/> Lap Width in/mm	<input type="checkbox"/> Lap Adhesion Type
<input type="checkbox"/> Air Retarder	<input type="checkbox"/> Vapor Retarder
Additional Detail:	

BASE SHEET SECUREMENT:

Base Sheet Adhesive Name:	Adhesive Application Rate:
Base Sheet Fastener Trade Name:	Type:
Head Diameter:	Length:
Spacing: (Attached Sketches as necessary)	
Spacing Along Laps: Zone 1':	Zone 1: Zone 2: Zone 3:
No. Intermediate Rows: Zone 1':	Zone 1: Zone 2: Zone 3:
Spacing Along Intermediate Rows: Zone 1':	Zone 1: Zone 2: Zone 3:
Additional Detail:	

CHECKLIST FOR ROOFING SYSTEM

DECK:

<input type="checkbox"/> Steel:	Manufacturer:	Type (e.g., wide rib):	Thickness / Gauge:	Yield Strength:
<input type="checkbox"/> LWIC (Form Deck):	<input type="checkbox"/> Cementitious Wood Fiber (<i>Pullout Test Required</i>):			
<input type="checkbox"/> Concrete:	<input type="checkbox"/> Pre-cast panels or <input type="checkbox"/> Cast in Place			
<input type="checkbox"/> Wood (<i>Pullout Test Required</i>):				
<input type="checkbox"/> Fiber Reinforced Cement:	<input type="checkbox"/> Fiber Reinforced Plastic			
<input type="checkbox"/> Gypsum (<i>Pullout Test Required</i>):	<input type="checkbox"/> Plank	or	<input type="checkbox"/> Poured	
<input type="checkbox"/> Other:				
Additional Detail:				

DECK or ROOF PANEL SECUREMENT:

Deck Or Roof Panel Fasteners:			Type:					
Trade Name:			Size Washer:					
Length:		Weld:		Washer:				
If Weld: Size:		Weld:		Washer:				
Fastener / Weld / External Seam Clamp (ESC) for Standing Seam Roof Spacing								
External Seam Clamp (ESC): Trade Name:								
Roof Slope deg.								
≤ 7			$>7, \leq 27$		$>27, \leq 45$			
Zone	Fastener / Weld Spacing	External Seam Clamp Spacing	Zone	Fastener / Weld Spacing	External Seam Clamp Spacing	Zone	Fastener / Weld Spacing	External Seam Clamp Spacing
1'								
1			1, 2e			1, 2e, 2r		
2			2n, 2r, 3e			2n, 3r		
3			3r			3e		
Deck Side Lap Fastener Spacing: Zone 1':			Zone 1:		Zone 2:		Zone 3:	
Additional Detail:								

ROOF STRUCTURE (Include Size, Gage, Etc.):

<input type="checkbox"/> Purlins	<input type="checkbox"/> "C" or	<input type="checkbox"/> "Z"	Thickness:
Purlin Spacing: Zone 1': Zone 1: Zone 2: Zone 3:			
<input type="checkbox"/> Joists	<input type="checkbox"/> Wood	or	<input type="checkbox"/> Steel
Joist Spacing: Zone 1': Zone 1: Zone 2: Zone 3:			
<input type="checkbox"/> Beams	<input type="checkbox"/> Wood	or	<input type="checkbox"/> Steel
Beam Spacing: Zone 1': Zone 1: Zone 2: Zone 3:			
<input type="checkbox"/> Other:			
Additional Detail:			

PERIMETER FLASHING: (Attach a detailed sketch of metal fascia, gravel stop, nailer, blocking, coping, etc.)

<input type="checkbox"/> FM Approved Flashing
<input type="checkbox"/> Other (<i>applicable only when FM Approved system is not available</i>):
Manufacturer/Trade Name:
Flashing Wind Rating: Zone 2 Zone 3
Fascia / Coping Detail: Face Height: Thickness:
Hook Strip Detail: Height: Thickness: Fastener spacing: Zone 2 Zone 3
Fastener Details: Length: Type & Diameter/No.
Nailer / Blocking Details Per FM Global Data Sheet 1-49? <input type="checkbox"/> Yes <input type="checkbox"/> No (<i>Attach Details</i>)
Nailer Securement: Diameter: Spacing: Zone 2 Zone 3 Embedment:
Additional Detail:

DRAINAGE:



CHECKLIST FOR ROOFING SYSTEM

For new construction: Has roof drainage been designed by a Qualified Engineer per FM Global Loss Prevention Data Sheet 1-54 and the local building code? <input type="checkbox"/> Yes <input type="checkbox"/> No (Attach details)
For re-roofing and recovering: Will the roof drainage be changed from the original design (i.e., drains inserted/covered/removed, new expansion joints, blocked or reduced scupper size)? <input type="checkbox"/> Yes <input type="checkbox"/> No If yes, were the changes reviewed by a Qualified Engineer? <input type="checkbox"/> Yes <input type="checkbox"/> No (Attach details)
Is secondary (emergency) roof drainage provided per FM Global Data Sheet 1-54? <input type="checkbox"/> Yes <input type="checkbox"/> No (Attach details)
Additional Detail:

ROOF MOUNTED EQUIPMENT: *(Attach drawings, calculations and any supporting detail.)*

Roof mounted equipment secured per FM Global Loss Prevention Data Sheet 1-28 and the local building code? <input type="checkbox"/> Yes <input type="checkbox"/> No
Additional Detail:

SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Low-slope roof sheet metal fabrications.
2. Wall sheet metal fabrications.
3. Miscellaneous sheet metal fabrications.

B. Related Requirements:

1. Section 04 22 00 "Concrete Unit Masonry" for materials and installation of manufactured sheet metal through-wall flashing and trim integral with masonry.
2. Section 07 53 23 "EPDM Roofing" for materials and installation of sheet metal flashing and trim integral with roofing.
3. Section 07 42 13.16 "Modular Metal Wall Panels" for sheet metal flashing and trim integral with metal wall panels and manufactured copings.
4. Section 07 71 00 "Roof Specialties" for roof-edge drainage systems.
5. Section 07 72 00 "Roof Accessories" for set-on-type curbs, equipment supports, roof hatches, and other manufactured roof accessory units.
6. Section 07 95 13.13 "Interior Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies for interior floors, walls, and ceilings.
7. Section 07 95 13.16 "Exterior Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies for exterior building walls, soffits, and parapets.

1.02 COORDINATION

- A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.
- B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.03 ACTION SUBMITTALS

- A. Product Data Submittals: For each type of product specified.
- B. Shop Drawings: For sheet metal flashing and trim.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Detail fabrication and installation layouts, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled Work.
 - 3. Include identification of material, thickness, weight, and finish for each item and location in Project.
 - 4. Include details for forming, including profiles, shapes, seams, and dimensions.
 - 5. Include details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
 - 6. Include details of termination points and assemblies.
 - 7. Include details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction from fixed points.
 - 8. Include details of roof-penetration flashing.
 - 9. Include details of special conditions.
 - 10. Include details of connections to adjoining work.
 - 11. Detail formed flashing and trim at scale of not less than 3 inches per 12 inches (1:5).

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For fabricator.
- B. Product Test Reports: For each product, for tests performed by a qualified testing agency.
- C. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sheet metal flashing and trim, and its accessories, to include in maintenance manuals.
- B. Special warranty.

1.06 QUALITY ASSURANCE

- A. Fabricator Qualifications: Employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.
- B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - 1. Build mockup of as shown on Drawings, including metal flashing and trim. Refer to Section 01 43 39 "Mockups."
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage.
 - 1. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
 - 2. Protect stored sheet metal flashing and trim from contact with water.
- B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Sheet metal flashing and trim assemblies, including cleats, anchors, and fasteners, are to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim are not to rattle, leak, or loosen, and are to remain watertight.
- B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing" and SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstraining of components,

failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.02 SHEET METALS

- A. Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.
- B. Stainless Steel Sheet: ASTM A240/A240M, Type 304, dead soft, fully annealed; with smooth, flat surface.
 1. Finish: ASTM A480/A480M, No. 2D (dull, cold rolled).
 - a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - (1) Run grain of directional finishes with long dimension of each piece.
 - (2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.03 MISCELLANEOUS MATERIALS

- A. Provide materials and types of fasteners, solder, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.
- B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
 1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
 - b. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.

- c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.
- 2. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.
- C. Solder:
 - 1. For Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.
- D. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
- E. Elastomeric Sealant: ASTM C920, elastomeric polyurethane polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

2.04 FABRICATION, GENERAL

- A. Custom fabricate sheet metal flashing and trim to comply with details indicated and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required.
 - 1. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
 - 2. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
 - 3. Verify shapes and dimensions of surfaces to be covered and obtain field measurements for accurate fit before shop fabrication.
 - 4. Form sheet metal flashing and trim to fit substrates without excessive oil-canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
 - 5. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.
- B. Fabrication Tolerances:
 - 1. Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

2. Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified.
- C. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.
 1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.
- D. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal in accordance with cited sheet metal standard to provide for proper installation of elastomeric sealant.
- E. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
- F. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard and by FM Global Property Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.
- G. Seams:
 1. Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
- H. Do not use graphite pencils to mark metal surfaces.

2.05 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

- A. Base Flashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- B. Counterflashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- C. Flashing Receivers: Fabricate from the following materials:
 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.
- D. Roof-Penetration Flashing: Fabricate from the following materials:
 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- E. Roof-Drain Flashing: Fabricate from the following materials:
 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.

2.06 WALL SHEET METAL FABRICATIONS

- A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch- (2400-mm) long, but not exceeding 12-foot- (3.6-m-) long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches (150 mm) beyond each side of wall openings; and form with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:
 - 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.
- B. Opening Flashings in Frame Construction: Fabricate head, sill, and similar flashings to extend 4 inches (100 mm) beyond wall openings. Form head and sill flashing with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:

- 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.

2.07 MISCELLANEOUS SHEET METAL FABRICATIONS

- A. Equipment Support Flashing: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances, substrate, and other conditions affecting performance of the Work.
 - 1. Verify compliance with requirements for installation tolerances of substrates.
 - 2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
 - 3. Verify that air- or water-resistant barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Install sheet metal flashing and trim to comply with details indicated and recommendations of cited sheet metal standard that apply to installation characteristics required unless otherwise indicated on Drawings.
 - 1. Install fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

2. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder.
 3. Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement.
 4. Install sheet metal flashing and trim to fit substrates and to result in watertight performance.
 5. Install continuous cleats with fasteners spaced not more than 12 inches (300 mm) o.c.
 6. Space individual cleats not more than 12 inches (300 mm) apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
 7. Install exposed sheet metal flashing and trim with limited oil-canning, and free of buckling and tool marks.
 8. Do not field cut sheet metal flashing and trim by torch.
 9. Do not use graphite pencils to mark metal surfaces.
- B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.
1. Coat concealed side of stainless steel sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim.
1. Space movement joints at maximum of 10 feet (3 m) with no joints within 24 inches (600 mm) of corner or intersection.
 2. Form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.
 3. Use lapped expansion joints only where indicated on Drawings.
- D. Fasteners: Use fastener sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.
- E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
- F. Seal joints as required for watertight construction.

- G. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter.

3.03 INSTALLATION OF WALL FLASHINGS

- A. Install sheet metal wall flashing to intercept and exclude penetrating moisture in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.

3.04 INSTALLATION OF MISCELLANEOUS FLASHING

- A. Equipment Support Flashing:
 - 1. Coordinate installation of equipment support flashing with installation of roofing and equipment.
 - 2. Weld or seal flashing with elastomeric sealant to equipment support member.

3.05 INSTALLATION TOLERANCES

- A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

3.06 CLEANING

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
- B. Clean and neutralize flux materials. Clean off excess solder.
- C. Clean off excess sealants.

3.07 PROTECTION

- A. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.
- B. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended in writing by sheet metal flashing and trim manufacturer.
- C. Maintain sheet metal flashing and trim in clean condition during construction.

- D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures, as determined by Engineer.

END OF SECTION

SECTION 07 71 00
ROOF SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Roof-edge drainage systems.

B. Related Requirements:

1. Section 07 42 13.16 "Modular Metal Wall Panels" for manufactured copings.
2. Section 07 62 00 "Sheet Metal Flashing and Trim" for custom- and site-fabricated sheet metal flashing and trim.
3. Section 07 72 00 "Roof Accessories" for set-on-type curbs, equipment supports, roof hatches, vents, and other manufactured roof accessory units.
4. Section 07 92 00 "Joint Sealants" for field-applied sealants between roof specialties and adjacent materials.

1.02 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For roof specialties.

1. Include plans, elevations, expansion-joint locations, keyed details, and attachments to other work. Distinguish between plant- and field-assembled work.
2. Include details for expansion and contraction; locations of expansion joints, including direction of expansion and contraction.
3. Indicate profile and pattern of seams and layout of fasteners, cleats, clips, and other attachments.
4. Detail termination points and assemblies, including fixed points.
5. Include details of special conditions.

C. Samples for Initial Selection: For each type of roof specialty indicated with factory-applied color finishes.

D. Samples for Verification:

1. Include Samples of each type of roof specialty to verify finish and color selection, in manufacturer's standard sizes.

1.03 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of roof specialty.

B. Sample Warranty: For manufacturer's special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing specialties to include in maintenance manuals.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Do not store roof specialties in contact with other materials that might cause staining, denting, or other surface damage. Store roof specialties away from uncured concrete and masonry.

B. Protect strippable protective covering on roof specialties from exposure to sunlight and high humidity, except to extent necessary for the period of roof-specialty installation.

1.06 FIELD CONDITIONS

A. Field Measurements: Verify profiles and tolerances of roof-specialty substrates by field measurements before fabrication, and indicate measurements on Shop Drawings.

B. Coordination: Coordinate roof specialties with flashing, trim, and construction of parapets, roof deck, roof and wall panels, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.07 WARRANTY

A. Special Warranty on Painted Finishes: Manufacturer agrees to repair finish or replace roof specialties that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:

- a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
- b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.

- c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
- 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. General Performance: Roof specialties to withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
- B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Provide clips that resist rotation and avoid shear stress as a result of thermal movements. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.02 ROOF-EDGE DRAINAGE SYSTEMS

- A. Downspouts: Plain square complete with mitered elbows, manufactured from the following exposed metal. Furnish with metal hangers, from same material as downspouts, and anchors.
 - 1. Extruded Aluminum: 0.125 inch (3.18 mm) thick.
- B. Parapet Scuppers: Manufactured with closure flange trim to exterior, 4-inch- (100-mm-) wide wall flanges to interior, and base extending 4 inches (100 mm) beyond cant or tapered strip into field of roof.
 - 1. Formed Aluminum: 0.032 inch (0.81 mm) thick.
- C. Conductor Heads: Manufactured conductor heads, each with flanged back and stiffened top edge, and of dimensions and shape indicated, complete with outlet tube that nests into upper end of downspout, exterior flange trim, and built-in overflow.
 - 1. Formed Aluminum: 0.032 inch (0.81 mm) thick.

2.03 MATERIALS

- A. Aluminum Sheet: ASTM B209 (ASTM B209M), alloy as standard with manufacturer for finish required, with temper to suit forming operations and performance required.

- B. Aluminum Extrusions: ASTM B221 (ASTM B221M), alloy and temper recommended by manufacturer for type of use and finish indicated, finished as follows:

2.04 MISCELLANEOUS MATERIALS

- A. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to meet performance requirements. Furnish the following unless otherwise indicated:
 - 1. Exposed Penetrating Fasteners: Gasketed screws with hex washer heads matching color of sheet metal.
 - 2. Fasteners for Aluminum: Aluminum or Series 300 stainless steel.

2.05 FINISHES

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- D. Coil-Coated Aluminum Sheet Finishes:
 - 1. High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Two-Coat Mica Fluoropolymer: AAMA 2605. Fluoropolymer finish with suspended mica flakes containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - b. Concealed Surface Finish: Apply pretreatment and manufacturer's standard acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).
- E. Aluminum Extrusion Finishes:
 - 1. High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Two-Coat Mica Fluoropolymer: AAMA 2605. Fluoropolymer finish with suspended mica flakes containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat. Prepare, pretreat, and apply

coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

- b. Concealed Surface Finish: Apply pretreatment and manufacturer's standard acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.
- B. Examine walls, roof edges, and parapets for suitable conditions for roof specialties.
- C. Verify that substrate is sound, dry, smooth, clean, sloped for drainage where applicable, and securely anchored.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Install roof specialties in accordance with manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, underlayments, sealants, and other miscellaneous items as required to complete roof-specialty systems.
 - 1. Install roof specialties level, plumb, true to line and elevation; with limited oil-canning and without warping, jogs in alignment, buckling, or tool marks.
 - 2. Provide uniform, neat seams with minimum exposure of solder and sealant.
 - 3. Install roof specialties to fit substrates and to result in weathertight performance. Verify shapes and dimensions of surfaces to be covered before manufacture.
 - 4. Torch cutting of roof specialties is not permitted.
 - 5. Do not use graphite pencils to mark metal surfaces.
- B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
- C. Expansion Provisions: Allow for thermal expansion of exposed roof specialties.
- D. Seal joints as required for weathertight construction. Place sealant to be completely concealed in joint. Do not install sealants at temperatures below 40 deg F (4 deg C).

3.03 INSTALLATION OF ROOF-EDGE DRAINAGE SYSTEMS

- A. Install components to produce a complete roof-edge drainage system in accordance with manufacturer's written instructions. Coordinate installation of roof perimeter flashing with installation of roof-edge drainage system.
- B. Downspouts: Join sections with manufacturer's standard telescoping joints. Provide hangers with fasteners designed to hold downspouts securely to walls and 1 inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1500 mm) o.c.
 - 1. Provide elbows at base of downspouts at grade to direct water away from building.
 - 2. Connect downspouts to underground drainage system indicated.
- C. Parapet Scuppers: Install scuppers through parapet where indicated. Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.
 - 1. Anchor scupper closure trim flange to exterior wall and seal or solder to scupper.
 - 2. Loosely lock front edge of scupper with conductor head.
 - 3. Seal or solder exterior wall scupper flanges into back of conductor head.
- D. Conductor Heads: Anchor securely to wall with elevation of conductor top edge 1 inch (25 mm) below scupper discharge.

3.04 CLEANING AND PROTECTION

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
- B. Clean and neutralize flux materials. Clean off excess solder and sealants.
- C. Remove temporary protective coverings and strippable films as roof specialties are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain roof specialties in a clean condition during construction.
- D. Replace roof specialties that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 72 00
ROOF ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Roof curbs.
2. Equipment supports.
3. Roof hatches.

B. Related Requirements:

1. Division 05 sections for floor access hatches, and metal vertical ladders and stairs for access to roof hatches.
2. Section 07 62 00 "Sheet Metal Flashing and Trim" for shop- and field-formed metal flashing, and miscellaneous sheet metal trim and accessories.
3. Section 07 71 00 "Roof Specialties" for manufactured gutters and downspouts, and counterflashing.
4. Section 11 24 29 "Facility Fall Protection" for ladder fall arrest systems including ladder extension posts.

1.02 COORDINATION

- A. Coordinate layout and installation of roof accessories with roofing membrane and base flashing and interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.
- B. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of roof accessory.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For roof accessories.

1. Include plans, elevations, keyed details, and attachments to other work. Indicate dimensions, loadings, and special conditions. Distinguish between plant- and field-assembled work.
- C. Samples: For each exposed product and for each color and texture specified, prepared on Samples of size to adequately show color.
- D. Delegated Design Submittals: For roof curbs and equipment supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Detail mounting, securing, and flashing of roof-mounted items to roof structure. Indicate coordinating requirements with roof membrane system.
 2. Wind-Restraint Details: Detail fabrication and attachment of wind restraints. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.04 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Roof plans, drawn to scale, and coordinating penetrations and roof-mounted items. Show the following:
 1. Size and location of roof accessories specified in this Section.
 2. Method of attaching roof accessories to roof or building structure.
 3. Other roof-mounted items including mechanical and electrical equipment, ductwork, piping, and conduit.
 4. Required clearances.
- B. Sample Warranties: For manufacturer's special warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For roof accessories to include in operation and maintenance manuals.

1.06 WARRANTY

- A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finishes or replace roof accessories that show evidence of deterioration of factory-applied finishes within specified warranty period.
 1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested according to ASTM D2244.

- b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
- 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. General Performance: Roof accessories to withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
- B. Delegated Design: Engage a qualified professional engineer to design roof curbs and equipment supports to comply with wind performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.02 ROOF CURBS

- A. Roof Curbs: Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings, bearing continuously on roof structure, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, straight sides, integral metal cant, and integrally formed deck-mounting flange at perimeter bottom.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AES Industries, Inc.
 - b. Air Balance; a division of MESTEK, Inc.
 - c. Greenheck Fan Corporation.
 - d. Pate Company (The).
 - e. Thybar Corporation.
- B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.
- C. Supported Load Capacity: Coordinate load capacity with information on Shop Drawings of equipment to be supported.
- D. Steel: Zinc-coated (galvanized) steel sheet, 0.052 inch (1.32 mm) thick.

1. Finish: Two-coat fluoropolymer.
2. Color: As selected by Engineer from manufacturer's full range.

E. Construction:

1. Curb Profile: Manufacturer's standard compatible with roofing system.
2. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
3. Fabricate curbs to minimum height of 12 inches (305 mm) above roofing surface unless otherwise indicated.
4. Top Surface: Level top of curb, with roof slope accommodated by sloping deck-mounting flange or by use of leveler frame.
5. Insulation: Factory insulated with 1-1/2-inch- (38-mm-) thick glass-fiber board insulation.
6. Liner: Same material as curb, of manufacturer's standard thickness and finish.
7. Nailer: Factory-installed wood nailer along top flange of curb, continuous around curb perimeter.
8. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb, of size and spacing required to meet wind uplift requirements.
9. Platform Cap: Where portion of roof curb is not covered by equipment, provide weathertight platform cap formed from 3/4-inch- (19-mm-) thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
10. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.

2.03 EQUIPMENT SUPPORTS

- A. Equipment Supports: Rail-type metal equipment supports capable of supporting superimposed live and dead loads between structural supports, including equipment loads and other construction indicated on Drawings, spanning between structural supports; capable of meeting performance requirements; with welded corner joints, integral metal cant, and integrally formed structure-mounting flange at bottom.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Activar Construction Products Group, Inc. - JL Industries.

- b. Air Balance; a division of MESTEK, Inc.
 - c. Greenheck Fan Corporation.
 - d. Pate Company (The).
 - e. Thybar Corporation.
- B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.
- C. Supported Load Capacity: Coordinate load capacity with information on Shop Drawings of equipment to be supported.
- D. Steel: Zinc-coated (galvanized) steel sheet, 0.052 inch (1.32 mm) thick.
 - 1. Finish: Two-coat fluoropolymer.
 - 2. Color: As selected by Engineer from manufacturer's full range.
- E. Construction:
 - 1. Curb Profile: Manufacturer's standard compatible with roofing system.
 - 2. Insulation: Factory insulated with 1-1/2-inch- (38-mm-) thick glass-fiber board insulation.
 - 3. Liner: Same material as equipment support, of manufacturer's standard thickness and finish.
 - 4. Nailer: Factory-installed continuous wood nailers 3-1/2 inches (90 mm) wide on top flange of equipment supports, continuous around support perimeter.
 - 5. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb of size and spacing required to meet wind uplift requirements.
 - 6. Platform Cap: Where portion of equipment support is not covered by equipment, provide weathertight platform cap formed from 3/4-inch- (19-mm-) thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
 - 7. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as equipment support.
 - 8. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
 - 9. Fabricate equipment supports to minimum height of 12 inches (305 mm) above roofing surface unless otherwise indicated.

2.04 ROOF HATCHES (RH-1, RH-2)

- A. Roof Hatches: Metal roof-hatch units with lids and insulated single-walled curbs, welded or mechanically fastened and sealed corner joints, continuous lid-to-curb counterflashing and weathertight perimeter gasketing, straight sides, and integrally formed deck-mounting flange at perimeter bottom.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Babcock-Davis Personnel Roof Hatch or comparable product by one of the following:
 - a. ACUDOR Products, Inc.
 - b. BILCO Company (The).
 - c. Milcor; a division of Hart & Cooley, Inc.
- B. Type and Size:
 - 1. Single-leaf lid, size as indicated on Drawings.
- C. Loads: Minimum 40-lbf/sq. ft. (1.9-kPa) external live load and 20-lbf/sq. ft. (0.95-kPa) internal uplift load.
- D. Hatch Material, Aluminum:
 - 1. Thickness: Manufacturer's standard thickness for hatch size indicated.
 - 2. Finish: Baked enamel or powder coat.
 - 3. Color: As selected by Engineer from manufacturer's full range.
- E. Construction:
 - 1. Insulation: 1-inch- (25-mm-) thick, polyisocyanurate board.
 - a. R-Value: 6 according to ASTM C1363.
 - 2. Nailer: Factory-installed wood nailer continuous around hatch perimeter.
 - 3. Hatch Lid: Opaque, insulated, and double walled, with manufacturer's standard metal liner of same material and finish as outer metal lid.
 - 4. Curb Liner: Manufacturer's standard, of same material and finish as metal curb.
 - 5. Fabricate curbs to minimum height of 12 inches (305 mm) above roofing surface unless otherwise indicated.

- F. Hardware: Spring operators, hold-open arm, stainless steel spring latch with turn handles, stainless steel butt- or pintle-type hinge system, and padlock hasps inside and outside.
- G. Safety Railing System: Roof-hatch manufacturer's standard system including rails, clamps, fasteners, safety barrier at railing opening, and accessories required for a complete installation; attached to roof hatch and complying with 29 CFR 1910.23 requirements and authorities having jurisdiction.
 - 1. Height: 42 inches (1060 mm) above finished roof deck.
 - 2. Posts and Rails: Galvanized-steel pipe, 1-1/4 inches (31 mm) in diameter or galvanized-steel tube, 1-5/8 inches (41 mm) in diameter.
 - 3. Flat Bar: Galvanized steel, 2 inches (50 mm) high by 3/8 inch (9 mm) thick.
 - 4. Maximum Opening Size: System constructed to prevent passage of a sphere 21 inches (533 mm) in diameter.
 - 5. Provide where shown:
 - a. Chain Passway Barrier: Galvanized proof coil chain with quick link on fixed end.
 - b. Self-Latching Gate: Fabricated of same materials and rail spacing as safety railing system. Provide manufacturer's standard hinges and self-latching mechanism.
 - 6. Post and Rail Tops and Ends: Weather resistant, closed or plugged with prefabricated end fittings.
 - 7. Provide weep holes or another means to drain entrapped water in hollow sections of handrail and railing members.
 - 8. Fabricate joints exposed to weather to be watertight.
 - 9. Fasteners: Manufacturer's standard, finished to match railing system.
 - 10. Finish: Manufacturer's standard.
 - a. Color: As selected by Engineer from manufacturer's full range.

2.05 ROOF HATCHES (RH-3, RH-4)

- A. Roof Hatches: Metal roof-hatch units with lids, welded or mechanically fastened and sealed corner joints, continuous counterflashing and weathertight perimeter gasketing, straight sides, and integrally formed deck-mounting flange at perimeter bottom.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Babcock-Davis Equipment Roof Hatch or comparable product by one of the following:
 - a. ACUDOR Products, Inc.
 - b. BILCO Company (The).
 - c. Milcor; a division of Hart & Cooley, Inc.
- B. Type and Size:
 1. Double-leaf lid, custom size as indicated on Drawings.
- C. Loads: Minimum 40-lbf/sq. ft. external live load and 20-lbf/sq. ft. internal uplift load.
- D. Hatch Material, Aluminum:
 1. Thickness: Manufacturer's standard thickness for hatch size indicated.
 2. Finish: Mill.
- E. Construction:
 1. Insulation: 1-inch fiberglass in cover.
 2. Nailer: Factory-installed wood nailer continuous around hatch perimeter.
 3. Hatch Lid: Opaque, insulated, and double walled, with manufacturer's standard metal liner of same material and finish as outer metal lid.
- F. Hardware: Spring operators, hold-open arm, stainless steel spring latch with turn handles, stainless steel butt- or pintle-type hinge system, and padlock hasps inside and outside.
 1. Provide two-point latch on lids larger than 84 inches.
- G. Safety Railing System: Roof-hatch manufacturer's standard system including rails, clamps, fasteners, safety barrier at railing opening, and accessories required for a complete installation; attached to roof hatch and complying with 29 CFR 1910.23 requirements and authorities having jurisdiction.
 1. Height: 42 inches (1060 mm) above finished roof deck.
 2. Posts and Rails: Galvanized-steel pipe, 1-1/4 inches (31 mm) in diameter or galvanized-steel tube, 1-5/8 inches (41 mm) in diameter.
 3. Flat Bar: Galvanized steel, 2 inches (50 mm) high by 3/8 inch (9 mm) thick.

4. Maximum Opening Size: System constructed to prevent passage of a sphere 21 inches (533 mm) in diameter.
5. Chain Passway Barrier: Galvanized proof coil chain with quick link on fixed end.
6. Post and Rail Tops and Ends: Weather resistant, closed or plugged with prefabricated end fittings.
7. Provide weep holes or another means to drain entrapped water in hollow sections of handrail and railing members.
8. Fabricate joints exposed to weather to be watertight.
9. Fasteners: Manufacturer's standard, finished to match railing system.
10. Finish: Manufacturer's standard.

2.06 ROOF HATCHES (RH-5, RH-6)

- A. Roof Hatches: Metal roof-hatch units with lids, welded or mechanically fastened and sealed corner joints, continuous counterflashing and weathertight perimeter gasketing, straight sides, and integrally formed deck-mounting flange at perimeter bottom.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Babcock-Davis Equipment Roof Hatch or comparable product by one of the following:
 - a. ACUDOR Products, Inc.
 - b. BILCO Company (The).
 - c. Milcor; a division of Hart & Cooley, Inc.
- B. Type and Size:
 1. Double-leaf lid, custom size as indicated on Drawings.
- C. Loads: Minimum 40-lbf/sq. ft. external live load and 20-lbf/sq. ft. internal uplift load.
- D. Hatch Material, Aluminum:
 1. Thickness: Manufacturer's standard thickness for hatch size indicated.
 2. Finish: Mill.
- E. Construction:
 1. Insulation: 1-inch fiberglass in cover.

2. Nailer: Factory-installed wood nailer continuous around hatch perimeter.
 3. Hatch Lid: Opaque, insulated, and double walled, with manufacturer's standard metal liner of same material and finish as outer metal lid.
- F. Hardware: Spring operators, hold-open arm, stainless steel spring latch with turn handles, stainless steel butt- or pintle-type hinge system, and padlock hasps inside and outside.
1. Provide two-point latch on lids larger than 84 inches.

2.07 METAL MATERIALS

- A. Zinc-Coated (Galvanized) Steel Sheet: ASTM A653/A653M, G90 (Z275) coating designation.
1. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A755/A755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Two-Coat Fluoropolymer Finish: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride (PVDF) resin by weight.
 2. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil (0.013 mm).
- B. Aluminum Sheet: ASTM B209 (ASTM B209M), manufacturer's standard alloy for finish required, with temper to suit forming operations and performance required.
1. Mill Finish: As manufactured.
 2. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 3. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil (0.013 mm).
- C. Aluminum Extrusions and Tubes: ASTM B221 (ASTM B221M), manufacturer's standard alloy and temper for type of use, finished to match assembly where used; otherwise mill finished.
- D. Stainless Steel Sheet and Shapes: ASTM A240/A240M or ASTM A666, Type 304.
- E. Steel Shapes: ASTM A36/A36M, hot-dip galvanized according to ASTM A123/A123M unless otherwise indicated.

- F. Steel Tube: ASTM A500/A500M, round tube.
- G. Galvanized-Steel Tube: ASTM A500/A500M, round tube, hot-dip galvanized according to ASTM A123/A123M.
- H. Steel Pipe: ASTM A53/A53M, galvanized.

2.08 MISCELLANEOUS MATERIALS

- A. Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.
- B. Glass-Fiber Board Insulation: ASTM C726, nominal density of 3 lb/cu. ft. (48 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C), thickness as indicated.
- C. Polyisocyanurate Board Insulation: ASTM C1289, thickness and thermal resistivity as indicated.
- D. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, acceptable to authorities having jurisdiction, containing no arsenic or chromium, and complying with AWPAC2; not less than 1-1/2 inches (38 mm) thick.
- E. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- F. Underlayment:
 - 1. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
- G. Fasteners: Roof accessory manufacturer's recommended fasteners suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners. Furnish the following unless otherwise indicated:
 - 1. Fasteners for Zinc-Coated Steel: Series 300 stainless steel or hot-dip zinc-coated steel according to ASTM A153/A153M or ASTM F2329.
 - 2. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
 - 3. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.
- H. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.

- I. Elastomeric Sealant: ASTM C920, elastomeric polyurethane polymer sealant as recommended by roof accessory manufacturer for installation indicated; low modulus; of type, grade, class, and use classifications required to seal joints and remain watertight.
- J. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for expansion joints with limited movement.

2.09 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.
- B. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
- C. Verify dimensions of roof openings for roof accessories.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install roof accessories according to manufacturer's written instructions.
 - 1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
 - 2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
 - 3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
 - 4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

- B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
 - 1. Coat concealed side of uncoated aluminum and stainless steel roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - 2. Underlayment: Where installing roof accessories directly on cementitious or wood substrates, install a course of underlayment and cover with manufacturer's recommended slip sheet.
 - 3. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof accessories for waterproof performance.
 - C. Roof Curb Installation: Install each roof curb so top surface is level.
 - D. Equipment Support Installation: Install equipment supports so top surfaces are level with each other.
 - E. Roof-Hatch Installation:
 - 1. Verify that roof hatch operates properly. Clean, lubricate, and adjust operating mechanism and hardware.
 - 2. Attach safety railing system to roof-hatch curb.
 - 3. Attach ladder-assist post according to manufacturer's written instructions.
 - F. Seal joints with elastomeric or butyl sealant as required by roof accessory manufacturer.
- 3.03 REPAIR AND CLEANING
- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A780/A780M.
 - B. Clean exposed surfaces according to manufacturer's written instructions.
 - C. Clean off excess sealants.
 - D. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 84 13

PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Penetration firestopping systems.
- B. Related Requirements:
 - 1. Section 07 84 43 "Joint Firestopping" for joints in or between fire-resistance-rated construction, at exterior curtain-wall/floor intersections, and in smoke barriers.

1.02 ACTION SUBMITTALS

- A. Product Data: Penetration firestopping systems.
- B. Product Schedule: For each penetration firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing and inspecting agency.
 - 1. Engineering Judgments: Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping system, submit illustration, with modifications marked, approved by penetration firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly developed in accordance with current International Firestop Council (IFC) guidelines. Obtain approval of authorities having jurisdiction prior to submittal.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Listed System Designs: For each penetration firestopping system, for tests performed by a qualified testing agency.

1.04 CLOSEOUT SUBMITTALS

- A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: A firm that has been approved by FM Approvals according to FM Approvals 4991, "Approval Standard for Firestop Contractors," or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."

1.06 PROJECT CONDITIONS

- A. Environmental Limitations: Do not install penetration firestopping system when ambient or substrate temperatures are outside limits permitted by penetration firestopping system manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.
- B. Install and cure penetration firestopping materials per manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.07 COORDINATION

- A. Coordinate construction of openings and penetrating items to ensure that penetration firestopping systems can be installed according to specified firestopping system design.
- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate penetration firestopping systems.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain penetration firestop systems for each type of opening indicated from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics:
 - 1. Perform penetration firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
 - 2. Test in accordance with testing standards referenced in "Penetration Firestopping Systems" Article. Provide rated systems complying with the following requirements:
 - a. Penetration firestop systems installed with products bearing the classification marking of a qualified product certification agency in accordance with listed system designs published by a qualified testing agency.
 - (1) UL in its online directory "Product iQ."
 - (2) Intertek Group in its "Directory of Building Products."
 - (3) FM Approvals in its "Approval Guide."

2.03 PENETRATION FIRESTOPPING SYSTEMS

- A. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems are to be compatible with one another, with the substrates forming openings, and with penetrating items if any.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. 3M Building and Construction.
 - b. A/D Fire Protection Systems Inc.
 - c. Balco; a CSW Industrials Company.
 - d. Grabber Construction Products, Inc.
 - e. Hilti, Inc.
 - f. Passive Fire Protection Partners.
 - g. Specified Technologies, Inc.
 - h. Tremco Incorporated.
- B. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.
 - 1. F-Rating: Not less than the fire-resistance rating of the wall penetrated.
 - 2. Membrane Penetrations: Install recessed fixtures such that the required fire resistance will not be reduced.
- C. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined per ASTM E814 or UL 1479.
 - 1. F-Rating: At least one hour, but not less than the fire-resistance rating of the floor penetrated.
 - 2. T-Rating: At least one hour, but not less than the fire-resistance rating of the floor. The following floor penetrations do not require a T-rating:
 - a. Those within the cavity of a wall.
 - b. 4-inch (200-mm) or smaller metal conduit penetrating directly into metal-enclosed electrical switchgear.

- 3. W-Rating: Provide penetration firestopping systems with a Class 1 W-rating in accordance with UL 1479.
- D. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, in accordance with ASTM E84.
- E. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.
 - 1. Permanent forming/damming/backing materials.
 - 2. Substrate primers.
 - 3. Collars.
 - 4. Steel sleeves.

2.04 FILL MATERIALS

- A. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer sleeve lined with an intumescent strip, a flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.
- B. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.
- C. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
- D. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced intumescent elastomeric sheet bonded to galvanized-steel sheet.
- E. Intumescent Putties: Nonhardening, water-resistant, intumescent putties containing no solvents or inorganic fibers.
- F. Intumescent Wrap Strips: Single-component intumescent elastomeric strips for use around combustible penetrants.
- G. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.
- H. Pillows/Bags: Compressible, removable, and reusable intumescent pillows encased in fire-retardant polyester or glass-fiber cloth. Where exposed, cover openings with steel-reinforcing wire mesh to protect pillows/bags from being easily removed.

- I. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
- J. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants.
- K. Fire-Rated Cable Sleeve Kits: Complete kits designed for new or existing cable penetrations through walls to accept standard accessories.
- L. Thermal Wrap: Flexible protective wrap tested and listed for up to 2-hour fire ratings in accordance with ASTM E814 or UL 1479 for membrane penetrations or ASTM E1725 or UL 1724 for thermal barrier and circuit integrity protection.
- M. Fire-Rated Cable Pathways: Single or gangable device modules composed of a steel raceway with integral intumescent material and requiring no additional action in the form of plugs, twisting closure, putty, pillows, sealant, or otherwise to achieve fire and air-leakage ratings.
- N. Retrofit Device for Cable Bundles: Factory-made, intumescent, collar-like device for firestopping existing over-filled cable sleeves and capable of being installed around projecting sleeves and cable bundles.
- O. Wall-Opening Protective Materials: Intumescent, non-curing putty pads or self-adhesive inserts for protection of electrical switch and receptacle boxes.
- P. Fire-Rated HVAC Retaining Angles: Steel angle system with integral intumescent firestop gasket for use around rectangular steel HVAC ducts without fire dampers.
- Q. Firestop Plugs: Flexible, re-enterable, intumescent, foam-rubber plug for use in blank round openings and cable sleeves.
- R. Fire-Rated Cable Grommet: Molded two-piece grommet made of plenum-grade polymer and foam inner core for sealing small cable penetrations in gypsum walls up to 1/2 inch (13 mm) in diameter.
- S. Closet Flange Gasket: Molded, single-component, flexible, intumescent gasket for use beneath a water closet (toilet) flange in floor applications.
- T. Endothermic Wrap: Flexible, insulating, fire-resistant, endothermic wrap for protecting membrane penetrations of utility boxes, critical electrical circuits, communications lines, and fuel lines.

2.05 MIXING

- A. Penetration Firestopping Materials: For those products requiring mixing before application, comply with penetration firestopping system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or

procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Surface Cleaning: Before installing penetration firestopping systems, clean out openings immediately to comply with manufacturer's written instructions and with the following requirements:
 - 1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of penetration firestopping materials.
 - 2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping materials. Remove loose particles remaining from cleaning operation.
 - 3. Remove laitance and form-release agents from concrete.
- B. Prime substrates where recommended in writing by manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.03 INSTALLATION OF PENETRATION FIRESTOPPING SYSTEMS

- A. General: Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.
- B. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.
 - 1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.
- C. Install fill materials by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.04 IDENTIFICATION

- A. Wall Identification: Permanently label walls containing penetration firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches (76 mm) high and with minimum 0.375-inch (9.5-mm) strokes.

1. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 feet (4.57 m) from end of wall and at intervals not exceeding 30 feet (9.14 m).

- B. Penetration Identification: Identify each penetration firestopping system with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches (150 mm) of penetration firestopping system edge so labels are visible to anyone seeking to remove penetrating items or firestopping systems. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

1. The words "Warning - Penetration Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Designation of applicable testing and inspecting agency.
4. Date of installation.
5. Manufacturer's name.
6. Installer's name.

3.05 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency to perform tests and inspections according to ASTM E2174.
- B. Where deficiencies are found or penetration firestopping system is damaged or removed because of testing, repair or replace penetration firestopping system to comply with requirements.

- C. Proceed with enclosing penetration firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.06 CLEANING AND PROTECTION

- A. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping system manufacturers and that do not damage materials in which openings occur.
- B. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping material and install new materials to produce systems complying with specified requirements.

END OF SECTION

SECTION 07 84 43
JOINT FIRESTOPPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Joints in or between fire-resistance-rated construction.

B. Related Requirements:

1. Section 07 84 13 "Penetration Firestopping" for penetrations in fire-resistance-rated walls, horizontal assemblies, and smoke barriers and for wall identification.
2. Section 07 95 13.13 "Interior Expansion Joint Cover Assemblies" for fire-resistive manufactured expansion-joint cover assemblies for interior floors, walls, and ceilings.
3. Section 07 95 13.16 "Exterior Expansion Joint Cover Assemblies" for fire-resistive manufactured expansion-joint cover assemblies for exterior building walls, soffits, and parapets.
4. Section 09 22 16 "Non-Structural Metal Framing" for firestop tracks for metal-framed partition heads.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Joints in or between fire-resistance-rated construction.

B. Product Schedule: For each joint firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing agency.

1. Engineering Judgments: Where Project conditions require modification to a qualified testing agency's illustration for a particular joint firestopping system condition, submit illustration, with modifications marked, approved by joint firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly developed in accordance with current International Firestop Council (IFC) guidelines.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

- B. Listed System Designs: For each joint firestopping system, for tests performed by a qualified testing agency.

1.04 CLOSEOUT SUBMITTALS

- A. Installer Certificates: From Installer indicating that joint firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: A firm that has been approved by FM Approvals according to FM Approvals 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with UL's "Qualified Firestop Contractor Program Requirements."

1.06 PROJECT CONDITIONS

- A. Environmental Limitations: Do not install joint firestopping systems when ambient or substrate temperatures are outside limits permitted by joint firestopping system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- B. Install and cure joint firestopping systems per manufacturer's written instructions using natural means of ventilation or, where this is inadequate, forced-air circulation.

1.07 COORDINATION

- A. Coordinate construction of joints to ensure that joint firestopping systems can be installed according to specified firestopping system design.
- B. Coordinate sizing of joints to accommodate joint firestopping systems.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain joint firestop systems for each type of joint opening indicated from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics:
 - 1. Perform joint firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
 - 2. Test per testing standards referenced in "Joint Firestopping Systems" Article. Provide rated systems complying with the following requirements:

- a. Joint firestop systems installed with products bearing the classification marking of a qualified product certification agency in accordance with Listed System Designs published by a qualified testing agency.

- (1) UL in its online directory "Product iQ."

- (2) Intertek Group in its "Directory of Building Products."

2.03 JOINT FIRESTOPPING SYSTEMS

- A. Joint Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which joint firestopping systems are installed. Joint firestopping systems must accommodate building movements without impairing their ability to resist the passage of fire and hot gases.

- 1. Joint firestopping systems that are compatible with one another, with the substrates forming openings, and with penetrating items, if any.
 - 2. Provide products that, upon curing, do not re-emulsify, dissolve, leach, breakdown, or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture.
 - 3. Provide firestop products that do not contain ethylene glycol.

- B. Intumescent Gypsum Wall Framing Gaskets (Applied to Steel Tracks, Runners, and Studs prior to Framing Installation): Provide products with fire, smoke, and acoustical ratings that allow movement up to 100 percent compression and/or extension in accordance with UL 2079 or ASTM E1966; have an L Rating less than 1 cfm/ft. (0.00115 cu. m/s x m) in accordance with UL 2079; and a minimum Sound Transmission Class (STC) rating of 56 in accordance with ASTM E90 or ASTM C919.

- C. Joints in or between Fire-Resistance-Rated Construction: Provide joint firestopping systems with ratings determined per ASTM E1966 or UL 2079.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A/D Fire Protection Systems Inc.
 - b. Balco; a CSW Industrials Company.
 - c. Grabber Construction Products, Inc.
 - d. Hilti, Inc.
 - e. Owens Corning.
 - f. Passive Fire Protection Partners.

- g. ROCKWOOL.
- h. Specified Technologies, Inc.
- 2. Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of the wall, floor, or roof in or between which it is installed.
- D. Exposed Joint Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E84.

2.04 ACCESSORIES

- A. Provide components of joint firestopping systems, including primers and forming materials, that are needed to install elastomeric fill materials and to maintain ratings required. Use only components specified by joint firestopping system manufacturer and approved by the qualified testing agency for conditions indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Surface Cleaning: Before installing joint firestopping systems, clean joints immediately to comply with fire-resistive joint system manufacturer's written instructions and the following requirements:
 - 1. Remove from surfaces of joint substrates foreign materials that could interfere with adhesion of elastomeric fill materials or compromise fire-resistive rating.
 - 2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with elastomeric fill materials. Remove loose particles remaining from cleaning operation.
 - 3. Remove laitance and form-release agents from concrete.
- B. Prime substrates where recommended in writing by joint firestopping system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

- C. Apply a suitable bond-breaker to prevent three-sided adhesion in applications where this condition occurs, such as the intersection of a gypsum wall to floor or roof assembly where the joint is backed by a steel ceiling runner or track.

3.03 INSTALLATION

- A. General: Install joint firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.
- B. Install forming materials and other accessories of types required to support elastomeric fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
 - 1. After installing elastomeric fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-resistive joint system.
- C. Install elastomeric fill materials for joint firestopping systems by proven techniques to produce the following results:
 - 1. Elastomeric fill voids and cavities formed by joints and forming materials as required to achieve fire-resistance ratings indicated.
 - 2. Apply elastomeric fill materials so they contact and adhere to substrates formed by joints.
 - 3. For elastomeric fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.04 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency to perform tests and inspections in accordance with ASTM E2393.
- B. Where deficiencies are found or joint firestopping systems are damaged or removed due to testing, repair or replace joint firestopping systems so they comply with requirements.
- C. Proceed with enclosing joint firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.05 CLEANING AND PROTECTION

- A. Clean off excess elastomeric fill materials adjacent to joints as the Work progresses by methods and with cleaning materials that are approved in writing by joint firestopping system manufacturers and that do not damage materials in which joints occur.
- B. Provide final protection and maintain conditions during and after installation that ensure joint firestopping systems are without damage or deterioration at time of Substantial

Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated joint firestopping systems immediately and install new materials to produce joint firestopping systems complying with specified requirements.

END OF SECTION

SECTION 07 92 00

JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Nonstaining silicone joint sealants.
2. Urethane joint sealants.
3. Mildew-resistant joint sealants.
4. Butyl joint sealants.
5. Latex joint sealants.

B. Related Requirements:

1. Division 03 Concrete specifications for sealants used in concrete fabrications.
2. Section 07 92 19 "Acoustical Joint Sealants" for sealing joints in sound-rated construction.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Nonstaining silicone joint sealants.
2. Urethane joint sealants.
3. Mildew-resistant joint sealants.
4. Butyl joint sealants.
5. Latex joint sealants.

B. Samples for Initial Selection: Manufacturer's standard color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

C. Samples for Verification: For each type and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.03 INFORMATIONAL SUBMITTALS

A. Preconstruction Laboratory Test Schedule: Include the following information for each joint sealant and substrate material to be tested:

1. Joint-sealant location and designation.
2. Manufacturer and product name.
3. Type of substrate material.
4. Proposed test.
5. Number of samples required.

B. Preconstruction Laboratory Test Reports: For each joint sealant and substrate material to be tested from sealant manufacturer, indicating the following:

1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
2. Interpretation of test results and written recommendations for primers and substrate preparation are needed for adhesion.

C. Preconstruction Field-Adhesion-Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.

D. Field Quality-Control Reports: For field-adhesion-test reports, for each sealant application tested.

E. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

A. Manufacturers' special warranties.

B. Installer's special warranties.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Qualified in accordance with ASTM C1021 to conduct the testing indicated.

1.06 MOCKUPS

- A. Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.

1.07 PRECONSTRUCTION TESTING

- A. Preconstruction Laboratory Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.
 - 1. Adhesion Testing: Use ASTM C794 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
 - 2. Compatibility Testing: Use ASTM C1087 to determine sealant compatibility when in contact with glazing and gasket materials.
 - 3. Stain Testing: Use ASTM C1248 to determine stain potential of sealant when in contact with masonry substrates.
 - 4. Submit manufacturer's recommended number of pieces of each type of material, including joint substrates, joint-sealant backings, and miscellaneous materials.
 - 5. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
 - 6. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures, including use of specially formulated primers.
 - 7. Testing will not be required if joint-sealant manufacturers submit data that are based on previous testing, not older than 24 months, of sealant products for adhesion to, staining of, and compatibility with joint substrates and other materials matching those submitted.
- B. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:
 - 1. Locate test joints where indicated on Project or, if not indicated, as directed by Engineer.

2. Conduct field tests for each kind of sealant and joint substrate.
3. Notify Engineer seven days in advance of dates and times when test joints will be erected.
4. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.
5. Test Method: Test joint sealants in accordance with Method A, Tail Procedure, in ASTM C1521.
 - a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
6. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.
7. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.08 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C).
 2. When joint substrates are wet.
 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.09 WARRANTY

- A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 1. Warranty Period: Two years from date of Substantial Completion.

- B. Special Manufacturer's Warranty: Manufacturer agrees to furnish joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
- C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
 - 1. Movement of the structure caused by stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
 - 2. Disintegration of joint substrates from causes exceeding design specifications.
 - 3. Mechanical damage caused by individuals, tools, or other outside agents.
 - 4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain joint sealants from single manufacturer for each sealant type.

2.02 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. Colors of Exposed Joint Sealants: As selected by Engineer from manufacturer's full range.

2.03 NONSTAINING SILICONE JOINT SEALANTS

- A. Nonstaining Joint Sealants: No staining of substrates when tested in accordance with ASTM C1248.
- B. Silicone, Nonstaining, S, NS, 50, NT: Nonstaining, single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 50, Use NT.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. GE Construction Sealants; Momentive Performance Materials Inc.

- b. Pecora Corporation.
- c. Sika Corporation; Joint Sealants.
- d. The Dow Chemical Company.
- e. Tremco Incorporated.

2.04 URETHANE JOINT SEALANTS

A. Urethane, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, urethane joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. BASF Corporation.
- b. Bostik, Inc.
- c. Pecora Corporation.
- d. Sherwin-Williams Company (The).
- e. Sika Corporation; Joint Sealants.
- f. Tremco Incorporated.

B. Urethane, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. BASF Corporation.
- b. Pecora Corporation.
- c. Sherwin-Williams Company (The).

C. Urethane, M, P, 25, T, NT: Multicomponent, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C920, Type M, Grade P, Class 25, Uses T and NT.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. BASF Corporation.
- b. Bostik, Inc.
- c. Pecora Corporation.
- d. Sherwin-Williams Company (The).
- e. Sika Corporation; Joint Sealants.
- f. Tremco Incorporated.

2.05 MILDEW-RESISTANT JOINT SEALANTS

- A. Mildew-Resistant Joint Sealants: Formulated for prolonged exposure to humidity with fungicide to prevent mold and mildew growth.
- B. Silicone, Mildew Resistant, S, NS, 25, NT: Mildew-resistant, single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. GE Construction Sealants; Momentive Performance Materials Inc.
 - b. Sika Corporation - Building Components.
 - c. The Dow Chemical Company.
 - d. Tremco Incorporated.

2.06 BUTYL JOINT SEALANTS

- A. Butyl-Rubber-Based Joint Sealants: ASTM C1311.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bostik, Inc.
 - b. Pecora Corporation.

2.07 LATEX JOINT SEALANTS

- A. Acrylic Latex: Acrylic latex or siliconized acrylic latex, ASTM C834, Type OP, Grade NF.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pecora Corporation.
 - b. Sherwin-Williams Company (The).
 - c. Tremco Incorporated.

2.08 JOINT-SEALANT BACKING

- A. Sealant Backing Material, General: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C1330, Type C (closed-cell material with a surface skin) or type, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.09 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. **Surface Cleaning of Joints:** Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - a. Concrete.
 - b. Masonry.
 3. Remove laitance and form-release agents from concrete.
 4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
 - a. Metal.
 - b. Glass.
 - c. Porcelain enamel.
 - d. Glazed surfaces of ceramic tile.
- B. **Joint Priming:** Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. **Masking Tape:** Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.03 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants in accordance with requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - 3. Provide concave joint profile in accordance with Figure 8A in ASTM C1193 unless otherwise indicated.

3.04 FIELD QUALITY CONTROL

- A. Testing Agency: Owner may engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
 - a. Extent of Testing: Test completed and cured sealant joints as follows:
 - (1) Perform 10 tests for the first 1000 ft. (300 m) of joint length for each kind of sealant and joint substrate.
 - (2) Perform one test for each 1000 ft. (300 m) of joint length thereafter or one test per each floor per elevation.
 - b. Test Method: Test joint sealants in accordance with Method A, Tail Procedure, in ASTM C1521.
 - (1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
 - c. Inspect tested joints and report on the following:
 - (1) Whether sealants filled joint cavities and are free of voids.
 - (2) Whether sealant dimensions and configurations comply with specified requirements.
 - (3) Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion complies with sealant manufacturer's field-adhesion hand-pull test criteria.
 - d. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant material, sealant configuration, and sealant dimensions.
 - e. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.
2. Evaluation of Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

- C. Prepare test and inspection reports.

3.05 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.06 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.07 JOINT-SEALANT SCHEDULE

- A. Joint-Sealant Application: Exterior joints in horizontal traffic surfaces.

- 1. Joint Locations:

- a. Isolation and contraction joints in cast-in-place concrete slabs, unless otherwise specified in Division 03.

- 2. Joint Sealant: Urethane, M, P, 25, T, NT.

- B. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces.

- 1. Joint Locations:

- a. Control and expansion joints in unit masonry.
 - b. Joints between metal panels.
 - c. Joints between different materials listed above.
 - d. Perimeter joints between materials listed above and frames of doors and windows.

- 2. Joint Sealant: Silicone, nonstaining, S, NS, 50, NT.

- C. Joint-Sealant Application: Interior joints in horizontal traffic surfaces.

- 1. Joint Locations:

- a. Isolation joints in cast-in-place concrete slabs, unless otherwise specified in Division 03.
 - b. Control and expansion joints in tile flooring.
- 2. Joint Sealant: Urethane, S, P, 25, T, NT.
- D. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces.
 - 1. Joint Locations:
 - a. Control and expansion joints on exposed interior surfaces of exterior walls.
 - b. Vertical joints on exposed surfaces of unit masonry walls.
 - 2. Joint Sealant: Urethane, S, NS, 25, NT.
- E. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces not subject to significant movement.
 - 1. Joint Locations:
 - a. Control joints on exposed interior surfaces of exterior walls.
 - b. Perimeter joints between interior wall surfaces and frames of interior doors and windows.
 - 2. Joint Sealant: Acrylic latex.
- F. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces.
 - 1. Joint Locations:
 - a. Joints between plumbing fixtures and adjoining walls, floors, and counters.
 - 2. Joint Sealant: Silicone, mildew resistant, S, NS, 25, NT.
- G. Joint-Sealant Application: Concealed mastics.
 - 1. Joint Locations:
 - a. Aluminum thresholds.
 - 2. Joint Sealant: Butyl-rubber based.

END OF SECTION

SECTION 07 92 19

ACOUSTICAL JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Acoustical joint sealants.

B. Related Requirements:

1. Section 07 92 00 "Joint Sealants" for elastomeric, latex, and butyl-rubber-based joint sealants for nonacoustical applications.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Acoustical joint sealants.

B. Acoustical Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.03 INFORMATIONAL SUBMITTALS

A. Test and Evaluation Reports:

1. Product Test Reports: For each type of acoustical joint sealant, for tests performed by qualified testing agency.

B. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

A. Warranty Documentation:

1. Installer's special warranties.

1.05 WARRANTY

- A. Installer's Special Warranty: Installer agrees to repair or replace acoustical joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 ACOUSTICAL JOINT SEALANT

- A. Acoustical joint-sealant products that effectively reduce airborne sound transmission through perimeter joints and openings in building construction, as demonstrated by testing representative assemblies in accordance with ASTM E90.
- B. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex acoustical sealant complying with ASTM C834.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. GE Construction Sealants; Momentive Performance Materials Inc.
 - b. Grabber Construction Products, Inc.
 - c. Hilti, Inc.
 - d. Pecora Corporation.
 - e. Specified Technologies, Inc.
 - 2. Colors of Exposed Acoustical Joint Sealants: White; provide paintable sealant where exposed.

2.02 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by acoustical joint-sealant manufacturer where required for adhesion of sealant to joint substrates.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine joints indicated to receive acoustical joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing acoustical joint sealants to comply with joint-sealant manufacturer's written instructions.
- B. Joint Priming: Prime joint substrates where recommended by acoustical joint-sealant manufacturer. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.03 INSTALLATION OF ACOUSTICAL JOINT SEALANTS

- A. Comply with acoustical joint-sealant manufacturer's written installation instructions unless more stringent requirements apply.
- B. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical joint sealant. Install acoustical joint sealants at both faces of partitions, at perimeters, and through penetrations. Comply with ASTM C919, ASTM C1193, and manufacturer's written instructions for closing off sound-flanking paths around or through assemblies, including sealing partitions to underside of floor slabs above acoustical ceilings.
- C. Acoustical Ceiling Areas: Apply acoustical joint sealant at perimeter edge moldings of acoustical ceiling areas in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.

3.04 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of acoustical joint sealants and of products in which joints occur.

3.05 PROTECTION

- A. Protect acoustical joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated acoustical joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION

SECTION 07 95 13.13

INTERIOR EXPANSION JOINT COVER ASSEMBLIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wall expansion joint covers.
2. Ceiling expansion joint covers.

1.02 ACTION SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for expansion joint cover assemblies.

1. Wall expansion joint covers.
2. Ceiling expansion joint covers.

B. Shop Drawings: For each expansion joint cover assembly.

1. Include plans, elevations, sections, details, splices, block-out requirement, attachments to other work, and line diagrams showing entire route of each expansion joint.
2. Where expansion joint cover assemblies change planes, provide isometric or clearly detailed drawing depicting how components interconnect.

C. Samples: For each expansion joint cover assembly and for each color and texture specified, full width by 6 inches (150 mm) long in size.

D. Expansion Joint Cover Assembly Schedule: Prepared by or under the supervision of the supplier. Include the following information in tabular form:

1. Manufacturer and model number for each expansion joint cover assembly.
2. Expansion joint cover assembly location cross-referenced to Drawings.
3. Nominal, minimum, and maximum joint width.
4. Movement direction.
5. Materials, colors, and finishes.

6. Product options.
7. Fire-resistance ratings.

1.03 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each fire-resistance-rated expansion joint cover assembly, for tests performed by a qualified testing agency.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION

- A. Furnish units in longest practicable lengths to minimize field splicing.
- B. Include factory-fabricated closure materials and transition pieces, T-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous expansion joint cover assemblies.

2.02 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Expansion joint cover assemblies to withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Expansion Joint Design Criteria:
 1. Type of Movement: Thermal.
 - a. Nominal Joint Width: As indicated on Drawings.
 2. Seismic Movement:
 - a. Joint Movement: As indicated on Drawings.

2.03 WALL AND CEILING EXPANSION JOINT COVERS

- A. Elastomeric-Seal Wall Joint Cover: Assembly consisting of elastomeric seal anchored to frames fixed to sides of joint gap.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide inpro Corporation; 113 Series. or a comparable product by one of the following:
 - a. Balco; a CSW Industrials Company.
 - b. Construction Specialties, Inc.
 - c. MM Systems Corporation.

- d. Nystrom, Inc.
- 2. Application: Wall to wall and Ceiling to Ceiling.
- 3. Exposed Metal:
 - a. Aluminum: Clear anodic, Class I.
- 4. Seal: Flat Santoprene Seal.
 - a. Dual durometer extruded Santoprene with Shore Hardness of 60 Shore A and 40 Shore D to ensure longevity of installation. Single durometer seals shall not be allowed.
 - b. Flat seal must maintain inherent dimensional stability and include structural spine inserts (where applicable) allowing for additional load resistance.
 - c. Color: As selected by Engineer from manufacturer's full range.

2.04 MATERIALS

- A. Aluminum: ASTM B221 (ASTM B221M), Alloy 6063-T5 for extrusions; ASTM B209 (ASTM B209M), Alloy 6061-T6 for sheet and plate.
 - 1. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.
- B. Elastomeric Seals: Manufacturer's standard preformed elastomeric membranes or extrusions to be installed in metal frames.

2.05 ALUMINUM FINISHES

- A. Mill finish.
- B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

2.06 ACCESSORIES

- A. Manufacturer's stainless steel attachment devices. Include anchors, clips, fasteners, set screws, spacers, and other accessories compatible with material in contact, as indicated or required for complete installations.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surfaces where expansion joint cover assemblies will be installed for installation tolerances and other conditions affecting performance of the Work.

- B. Notify Engineer where discrepancies occur that will affect proper expansion joint cover assembly installation and performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Prepare substrates according to expansion joint cover assembly manufacturer's written instructions.
- B. Coordinate and furnish anchorages, setting drawings, and instructions for installing expansion joint cover assemblies. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of expansion joint cover assemblies.

3.03 INSTALLATION

- A. Comply with manufacturer's written instructions for storing, handling, and installing expansion joint cover assemblies and materials unless more stringent requirements are indicated.
- B. Metal Frames: Perform cutting, drilling, and fitting required to install expansion joint cover assemblies.
 - 1. Repair or grout block out as required for continuous frame support using nonmetallic, shrinkage-resistant grout.
 - 2. Install frames in continuous contact with adjacent surfaces.
 - a. Shimming is not permitted.
 - 3. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
 - 4. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation.
 - 5. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
 - 6. Locate anchors at interval recommended by manufacturer, but not less than 3 inches (75 mm) from each end and not more than 24 inches (600 mm) o.c.
- C. Seals: Install elastomeric seals and membranes in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.
 - 1. Provide in continuous lengths for straight sections.

2. Seal transitions. Vulcanize or heat-weld field-spliced joints as recommended by manufacturer.
 3. Installation: Mechanically lock seals into frames or adhere to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
- D. Install with hairline mitered corners where expansion joint cover assemblies change direction or abut other materials.
 - E. Terminate exposed ends of expansion joint cover assemblies with field- or factory-fabricated termination devices.
- 3.04 PROTECTION
- A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.
 - B. Protect the installation from damage by work of other Sections. Where necessary due to heavy construction traffic, remove and properly store cover plates or seals and install temporary protection over expansion joint cover assemblies. Reinstall cover plates or seals prior to Substantial Completion.

END OF SECTION

SECTION 07 95 13.16

EXTERIOR EXPANSION JOINT COVER ASSEMBLIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Exterior expansion joint covers.

1.02 ACTION SUBMITTALS

- A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for expansion joint cover assemblies.
 - 1. Exterior expansion joint covers.
- B. Samples for Initial Selection: For each type of exposed finish.
 - 1. Include manufacturer's color charts showing the full range of colors and finishes available for each exposed metal and elastomeric seal material.
- C. Samples for Verification: For each type of expansion joint cover assembly, full width by 6 inches (150 mm) long in size.

1.03 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each fire-resistance-rated expansion joint cover assembly, for tests performed by a qualified testing agency.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION

- A. Furnish units in longest practicable lengths to minimize field splicing.
- B. Include factory-fabricated closure materials and transition pieces, T-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous expansion joint cover assemblies.

2.02 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Expansion joint cover assemblies shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Expansion Joint Design Criteria:

1. Type of Movement: Thermal.
 - a. Nominal Joint Width: As indicated on Drawings.
2. Seismic Movement:
 - a. Joint Movement: As indicated on Drawings.

2.03 EXTERIOR EXPANSION JOINT COVERS

- A. Preformed Foam Joint Seals: Manufacturer's standard joint seal manufactured from urethane or EVA (ethylene vinyl acetate) foam with minimum density of 10 lb/cu. ft. (160 kg/cu. m) and impregnated with a nondrying, water-repellent agent. Factory produce in precompressed sizes in roll or stick form to fit joint widths based on design criteria indicated, with factory- or field-applied adhesive for bonding to substrates and a silicone cover membrane.
1. Basis-of-Design Product: Subject to compliance with requirements, provide EMSEAL Joint Systems, Ltd; Seismic Colorseal or a comparable product by one of the following:
 - a. Balco; a CSW Industrials Company.
 - b. MM Systems Corporation.
 - c. Nystrom, Inc.
 2. Design Criteria:
 - a. Movement Capability: 100 percent.
 3. Joint Seal Color: As selected by Engineer from full range of industry colors.

2.04 MATERIALS

- A. Elastomeric Seals: Manufacturer's standard preformed elastomeric membranes or extrusions to be installed in metal frames.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surfaces where expansion joint cover assemblies will be installed for installation tolerances and other conditions affecting performance of the Work.

- B. Notify Engineer where discrepancies occur that will affect proper expansion joint cover assembly installation and performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Prepare substrates according to expansion joint cover assembly manufacturer's written instructions.

3.03 INSTALLATION

- A. Comply with manufacturer's written instructions for storing, handling, and installing expansion joint cover assemblies and materials unless more stringent requirements are indicated.
- B. Preformed Foam Joint Seals: Install in compliance with manufacturer's written instructions. Install with minimum number of end joints.
 - 1. Install each length of seal immediately after removing protective wrapping.
 - 2. Firmly secure compressed joint seals to joint gap side to obtain full bond using exposed pressure-sensitive adhesive or field-applied adhesive as recommended by manufacturer.
 - 3. Do not pull or stretch material. Produce seal continuity at splices, ends, turns, and intersections of joints.
 - 4. For applications at low ambient temperatures, heat foam joint seal material in compliance with manufacturer's written instructions.
- C. Terminate exposed ends of expansion joint cover assemblies with field- or factory-fabricated termination devices.

3.04 PROTECTION

- A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.
- B. Protect the installation from damage by work of other Sections.

END OF SECTION

SECTION 08 11 16

ALUMINUM DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Interior and exterior aluminum doors, door frames, and glazing frames. (ALUM-1)

B. Related Requirements:

1. Section 08 14 16 "Flush Wood Doors" for wood doors installed in aluminum frames.
2. Section 08 41 13 "Aluminum-Framed Entrances and Storefronts" for glazed interior and exterior aluminum doors and frames (ALUM-2)

1.02 COORDINATION

- ###### A.
- Coordinate anchorage installation for aluminum frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.
- ###### B.
- Coordinate requirements for installation of door hardware, electrified door hardware, and access control and security systems.

1.03 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

1. Include construction details, material descriptions, core descriptions, and finishes.

B. Shop Drawings: Include the following:

1. Elevations of each door type.
2. Details of doors, including vertical and horizontal edge details and metal thicknesses.
3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
4. Locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.

6. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
 7. Details of anchorages, joints, field splices, and connections.
 8. Details of accessories.
 9. Details of moldings, removable stops, and glazing.
- C. Product Schedule: For aluminum doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver aluminum doors and frames palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
- B. Store aluminum doors and frames under cover at Project site with head up. Place units on minimum 4-inch- (100-mm-) high wood blocking.
- C. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.01 ALUMINUM DOORS AND FRAMES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Special-Lite SL-16 Door and Aluminum Tube Framing or comparable product by one of the following:
 1. Capitol Aluminum and Glass Corp.
 2. Cline Doors
 3. CMI Architectural
 4. Cross Aluminum
 5. Kawneer
- B. Source Limitations: Obtain aluminum doors and frames from single source from single manufacturer.

2.02 ALUMINUM DOORS

- A. Door Thickness: 1-3/4 inches.

B. Stiles and Rails:

1. Aluminum extrusions made from 6063 aluminum alloys with a minimum temper of T5.
2. Minimum 2-5/16 inches deep one-piece extrusion with have integral reglets to accept face sheet on both interior and exterior side of door which secure face sheet into place and permit flush appearance.
3. Screw or snap in place applied caps are not acceptable.
4. Top rails must have integral legs for interlocking continuous extruded aluminum flush cap.
5. Bottom rails must have integral legs for interlocking continuous weather bar with single nylon brush weather stripping or manually adjustable SL-301 door bottom with two nylon brush weather stripping.
6. Meeting stiles to include integral pocket to accept pile brush weather seal.

C. Corners:

1. Mitered.
2. Secured with 3/8-inch diameter full-width steel tie rod through extruded splines top and bottom which are integral to standard tubular shaped rails.
3. 1-1/4 inches x 1-1/4 inches x 3/16-inch 6061 aluminum angle reinforcement at corner to give strong, flat surface for locking hex nut to bear on.
4. Weld, glue, or other methods of corner joinery are not acceptable.

D. Core:

1. Poured-in-place polyurethane foam.
2. Laid in foam cores are not acceptable.
3. Foam Plastic Insulated Doors: IBC 2603.4.
 - a. Foam plastic shall be separated from the interior of a building by an approved thermal barrier.
 - b. Approved thermal barrier must meet the acceptance criteria of the Temperature Transmission Fire Test and Integrity Fire Test as stated in NFPA 275.

- c. IBC 2603.4.1.7 foam plastic insulation, having a flame spread index less than 75 and a smoke developed index of not more than 450 shall be permitted as a door core when the face is metal minimum 0.032" aluminum or 0.016" steel.
- d. Standard door assembly can be tested to show it meets these requirements without the use of thermal barrier. If no independent testing conducted all doors with foam plastic core must have a thermal barrier.

E. Face Sheet:

- 1. Interior and exterior 0.125-inch thick smooth aluminum sheet.
- 2. Attachment of face sheet.
 - a. Extruded stiles and rails to have integral reglets to accept face sheet on both interior and exterior side of door which secure face sheet into place and permit flush appearance.
 - b. Use of glue to bond face sheet to core or extrusions is not acceptable.

F. Hardware:

- 1. Pre-machine doors in accordance with templates from specified hardware manufacturers.
- 2. Surface mounted closures will be reinforced for but not prepped or installed at factory.
- 3. Factory install door hardware.

G. Reinforcements:

- 1. Aluminum extrusions made from 6061 or 6063 aluminum alloys.
- 2. Sheet and plate to conform to ASTM-B209.
- 3. Alloy and temper to be selected by manufacturer for strength, corrosion resistance, and application of required finish, and control of color.
- 4. Bars and tubes to meet ASTM-B221.

2.03 ALUMINUM FRAMES

A. Aluminum Tube Framing with Applied Stops at Interior Doors:

- 1. Materials:
 - a. Aluminum extrusions made 6061 or 6063 aluminum alloys.

- b. Sheet and plate to conform to ASTM-B209.
 - c. Alloy and temper to be selected by manufacturer for strength, corrosion resistance, and application of required finish, and control of color.
- 2. Perimeter Frame Members:
 - a. Box type with 4 enclosed sides.
 - b. Factory fabricated.
 - c. Open-back framing is not acceptable.
- 3. Applied Door Stops:
 - a. 0.125-inch wall thickness, with screws and weather-stripping.
 - b. Provide solid 1/2-inch aluminum bar behind door stop for closer shoe attachment.
 - c. Pressure gasketing for weathering seal.
 - d. Counterpunch fastener holes in door stop to preserve full-metal thickness under fastener head.
- 4. Caulking: Caulk joints before assembling frame members.
- 5. Secure joints with fasteners and provide hairline butt joint appearance.
- 6. Pre-machine and reinforce frame members for hardware in accordance with manufacturer's standards and door hardware schedule. Factory install door hardware.
- 7. Anchors:
 - a. Anchors appropriate for wall conditions to anchor framing to wall materials.
 - b. Door Jamb and Header Mounting Holes: Maximum of 24-inch centers.
 - c. Secure head and sill members of transom, side lites, and similar conditions.
- B. Thermally Broken Aluminum Framing at Exterior Doors:
 - 1. Perimeter Frame Members:
 - a. Storefront frame with thermally broken pocket filler.
 - b. Factory fabricated.

- c. Open-back framing is not acceptable.
- 2. Thermal Strut: Fiber reinforced plastic, no other materials will be accepted.
- 3. Applied Door Stops:
 - a. 0.125-inch wall thickness, with screws and weather-stripping.
 - b. Provide solid 1/2-inch aluminum bar behind door stop for closer shoe attachment.
 - c. Pressure gasketing for weathering seal.
 - d. Counterpunch fastener holes in door stop to preserve full-metal thickness under fastener head.
 - e. Minimum 1/2-inch aluminum bar reinforcement under doorstep for required hardware attachments, aluminum to meet ASTM-B221.
- 4. Caulk joints before assembling frame members.
- 5. Frame Member to Member Connections.
 - a. Secure joints with fasteners.
 - b. Provide hairline butt joint appearance.
 - c. Shear block construction only, no screw spline allowed.
- 6. Pre-machine and reinforce frame members for hardware in accordance with manufacturer's standards and door hardware schedule. Factory install door hardware.
- 7. Anchors:
 - a. Anchors appropriate for wall conditions to anchor framing to wall materials.
 - b. Door Jamb and Header Mounting Holes: Maximum of 24-inch centers.
 - c. Secure head and sill members of transom, side lites, and similar conditions.

2.04 ACCESSORIES

- A. Fasteners: Aluminum, nonmagnetic, stainless steel or other noncorrosive metal fasteners compatible with frames, stops, panels, reinforcement plates, hardware, anchors, and other items being fastened.
- B. Glazing Gaskets: Manufacturer's standard extruded or molded rubber or plastic, to accommodate glazing thickness indicated; in black.

- C. Glass: As specified in Section 08 80 00 "Glazing."
- D. Door Hardware: As specified in Section 08 71 00 "Door Hardware."

2.05 FABRICATION

- A. Provide concealed corner reinforcements and alignment clips for accurately fitted hairline joints at butted and mitered connections.
- B. Factory prepare aluminum doors and frames to receive templated mortised hardware; include cutouts, reinforcements, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in Section 08 71 00 "Door Hardware."
 - 1. Locate hardware cutouts and reinforcements as required by fire-rated label for assembly.
- C. Fabricate frames for glazing with removable stops to allow glazing replacement without dismantling frame.
 - 1. Locate removable stops on the inside of spaces accessed by keyed doors.
- D. Fabricate components to allow secure installation without exposed fasteners.

2.06 GENERAL FINISH REQUIREMENTS

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.07 ALUMINUM FINISHES

- A. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 1. Color: Medium Gray to match ALUM-2

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Verify that wall thickness does not exceed standard tolerances allowed by throat size of indicated aluminum frame.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install aluminum doors and frames plumb, rigid, properly aligned, and securely fastened in place; according to manufacturer's written instructions.
- B. Install frame components in the longest possible lengths with no piece less than 48 inches (1220 mm); components 72 inches (1830 mm) or shorter must be one piece.
 - 1. Use concealed installation clips to produce tightly fitted and aligned splices and connections.
 - 2. Secure clips to extruded main-frame components and not to snap-in or trim members.
 - 3. Do not leave screws or other fasteners exposed to view when installation is complete.
- C. Glass: Install glass according to Section 08 80 00 "Glazing" and aluminum-frame manufacturer's written instructions.
- D. Doors: Install doors aligned with frames and fitted with required hardware.
- E. Door Hardware: Install according to Section 08 71 00 "Door Hardware" and aluminum-frame manufacturer's written instructions.

3.03 ADJUSTING

- A. Inspect installation, correct misalignments, and tighten loose connections.
- B. Doors: Adjust doors to operate smoothly and easily, without binding or warping. Adjust hardware to function smoothly, and lubricate as recommended by manufacturer.
- C. Clean exposed frame surfaces promptly after installation, using cleaning methods recommended in writing by frame manufacturer and according to AAMA 609 and AAMA 610.
- D. Touch Up: Repair marred frame surfaces to blend inconspicuously with adjacent unrepaired surface as viewed by Engineer. Remove and replace frames with damaged finish that cannot be satisfactorily repaired.

END OF SECTION

SECTION 08 11 19

STAINLESS STEEL DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Stainless steel doors and frames.

B. Related Requirements:

1. Section 08 71 00 "Door Hardware" for door hardware for stainless steel doors.

1.02 COORDINATION

- A. Coordinate anchorage installation for stainless steel frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.
- B. Coordinate requirements for installation of door hardware, electrified door hardware, and access control and security systems.

1.03 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

1. Include construction details, material descriptions, core descriptions, fire-resistance ratings, and finishes.

B. Shop Drawings: Include the following:

1. Elevations of each door type.
2. Details of doors, including vertical and horizontal edge details and metal thicknesses.
3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
4. Locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.

6. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
 7. Details of anchorages, joints, field splices, and connections.
 8. Details of accessories.
 9. Details of moldings, removable stops, and glazing.
- C. Product Schedule: For stainless steel doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For door inspector.
1. Fire-Rated Door Inspector: Submit documentation of compliance with NFPA 80, Section 5.2.3.1.
 2. Submit copy of DHI Fire and Egress Door Assembly Inspector (FDAI) certificate.
- B. Product Test Reports: For each type of fire-rated stainless steel door and frame assembly and fire-rated borrowed-lite assembly for tests performed by a qualified testing agency indicating compliance with performance requirements.
- C. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

- A. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.06 QUALITY ASSURANCE

- A. Fire-Rated Door Inspector Qualifications: Inspector for field quality control inspections of fire-rated door assemblies must meet the qualifications set forth in NFPA 80, Section 5.2.3.1 and the following:
1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver stainless steel doors and frames palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
- B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

- C. Store stainless steel doors and frames under cover at Project site with head up. Place units on minimum 4-inch- (100-mm-) high wood blocking.
- D. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, acceptable to authorities having jurisdiction for fire-protection ratings indicated on Drawings, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.
 - 1. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
- B. Fire-Rated, Borrowed-Lite Frame Assemblies: Assemblies complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing in accordance with NFPA 257 or UL 9.

2.02 STAINLESS STEEL DOORS AND FRAMES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AMBICO Limited.
 - 2. Ceco Door; AADG, Inc.; ASSA ABLOY.
 - 3. Curries, AADG, Inc.; ASSA ABLOY Group.
 - 4. DE LA FONTAINE.
 - 5. Steelcraft; Allegion plc.
 - 6. Titan Metal Products.
- B. Construct stainless steel door and frame assemblies to comply with NAAMM-HMMA 866 for the application indicated, including materials, fabrication methods, hardware reinforcement, tolerances, and clearances, and as specified. Comply with SDI ANSI/A250.4, for Physical Performance Level A.

C. Doors and Frames for Highly Corrosive Environments:

1. Stainless Steel Doors:

- a. Type: As indicated in the Door and Frame Schedule on Drawings.
- b. Thickness: 1-3/4 inches (44.5 mm).
- c. Face Sheets: Type 316 stainless steel sheet, minimum thickness 0.050 inch (1.27 mm).
- d. Edge Construction: Continuously welded with no visible seam.
- e. Top and Bottom Edges: Closed with continuous stainless steel channels with minimum thickness of 0.062 inch (1.27 mm), welded to face sheets.
 - (1) Provide flush top and bottom closures for exterior doors, with weep holes at bottom edge.
- f. Fire-Rated Core: Manufacturer's standard vertical steel stiffener or laminated mineral board core for fire-rated doors.

2. Stainless Steel Frames:

- a. Materials: Type 316 stainless steel sheet.
- b. Door Frames for Openings 48 Inches (1219 mm) Wide or Less: Fabricate from stainless steel sheet, minimum thickness 0.062 inch (1.59 mm).
- c. Construction: Full profile welded.

3. Hardware Reinforcement: Stainless steel sheet.

4. Finish: ASTM A480/A480M No. 2B, Bright, Cold-Rolled, Unpolished.

2.03 MATERIALS

- A. Stainless Steel Sheet: ASTM A240/A240M, austenitic stainless steel, Type 316.
- B. Mineral-Fiber Insulation: Insulation made of rock-wool fibers, slag-wool fibers, or glass fibers.
- C. Inserts, Bolts, and Anchor Fasteners:
 - 1. Stainless steel components complying with ASTM F593 and ASTM F594, Alloy Group 1 or 2 for bolts and nuts.

2.04 FRAME ANCHORS

- A. Provide anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
- B. Postinstalled Expansion Anchor: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts, with manufacturer's standard pipe spacer.
- C. Number and Spacing:
 - 1. Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c.
 - 2. Compression Type: Not less than two anchors in each jamb.
 - 3. Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.
- D. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor.
- E. Material:
 - 1. Stainless steel sheet. Same type as door face.

2.05 FABRICATION

- A. Stainless Steel Door Fabrication: Provide doors rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal.
 - 1. Tolerances: Fabricate doors to tolerances indicated in NAAMM-HMMA 866.
- B. Stainless Steel Frame Fabrication: Provide stainless steel frames rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal.
 - 1. Tolerances: Fabricate frames to tolerances indicated in NAAMM-HMMA 866.
 - 2. Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as frames. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
 - 3. Borrowed-Lite Frames: Fabricate from minimum 0.062-inch- (1.59-mm-) thick, stainless steel sheet.

4. Provide countersunk, flat-, or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 5. Door Silencers: Except on weather-stripped and gasketed frames, drill stops to receive door silencers as follows. Provide plastic plugs to keep holes clear during construction.
 - a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
 6. Stops and Moldings: Provide stops and moldings formed integrally with stainless steel frames around glazed lites, minimum 5/8 inch (16 mm) high unless otherwise indicated. Form corners of stops and moldings with butted or mitered hairline joints.
 - a. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of door or frame.
 - b. Provide stops for installation with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.
 7. Provide stops for installation with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.
- C. Hardware Preparation: Factory prepare stainless steel doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping, in accordance with the Door Hardware Schedule on Drawings, and templates.
1. Reinforce doors to receive nontemplated mortised and surface-mounted door hardware.
 2. Comply with ANSI/BHMA A156.115 for preparing hollow-metal doors and frames for hardware.

2.06 FINISHES

- A. Stainless Steel Finishes: Remove tool and die marks and stretch lines, or blend into finish. Grind and polish surfaces to produce uniform finish, free of cross scratches. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
- B. Grain Direction: For finishes exhibiting grain, run grain vertically on door faces and frame jambs.

2.07 ACCESSORIES

- A. Glazing: Comply with requirements in Section 08 80 00 "Glazing."

- B. Mineral-Fiber Insulation: Insulation made of rock-wool fibers, slag-wool fibers, or glass fibers.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.
- B. Prior to installation and with installation spreaders in place, adjust and securely brace stainless steel door frames for squareness, alignment, twist, and plumb to the following tolerances:
 - 1. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb, and perpendicular to frame head.
 - 2. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - 3. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - 4. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.
- C. Drill and tap doors and frames to receive nontemplated mortised and surface-mounted door hardware.

3.02 INSTALLATION

- A. Install stainless steel doors and frames plumb, rigid, properly aligned, and securely fastened in place; comply with approved Shop Drawings and with manufacturer's written instructions.
- B. Stainless Steel Frames:
 - 1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, without damage to completed Work.
 - a. Where frames are fabricated in sections, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
 - b. Install frames with removable glazing stops located on secure side of opening.

2. Fire-Rated Openings: Install frames in accordance with NFPA 80.
3. Floor Anchors: Secure with postinstalled expansion anchors.
 - a. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
4. Solidly pack mineral-fiber insulation inside frames.
5. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors.
6. 6. Installation Tolerances: Adjust stainless steel frames for squareness, alignment, twist, and plumb to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb, and perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.

C. Stainless Steel Doors: Fit and adjust stainless steel doors accurately in frames within clearances specified below:

1. Fire-Rated Doors: Install doors with clearances in accordance with NFPA 80.

D. Glazing: Install glazing in borrowed lites to comply with installation requirements in Section 08 80 00 "Glazing."

3.03 FIELD QUALITY CONTROL

- A. Inspection Agency: Engage a qualified inspector to perform inspections and to furnish reports to Engineer.
- B. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, Section 5.2.
- C. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- D. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.

- E. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in NFPA 80.

3.04 ADJUSTING AND CLEANING

- A. Clean grout and other bonding material off stainless steel doors and frames immediately after installation.
- B. Stainless Steel Touchup: Immediately after erection, smooth any scratched or damaged areas of stainless steel; polish to match undamaged finish.

END OF SECTION

SECTION 08 14 16
FLUSH WOOD DOORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Solid-core five-ply flush wood veneer-faced doors for transparent finish.

B. Related Requirements:

1. Section 08 11 16 "Aluminum Doors and Frames" for aluminum door frame systems.

1.02 ACTION SUBMITTALS

A. Product Data Submittals: For each product, including the following:

1. Door core materials and construction.
2. Door edge construction
3. Door face type and characteristics.
4. Factory- finishing specifications.

B. Shop Drawings: Indicate location, size, and hand of each door; elevation of each type of door; construction details not covered in Product Data; and the following:

1. Door schedule indicating door location, type, size, fire protection rating, and swing.
2. Door elevations, dimension and locations of hardware, lite and louver cutouts, and glazing thicknesses.
3. Details of frame for each frame type, including dimensions and profile.
4. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
5. Dimensions and locations of blocking for hardware attachment.
6. Dimensions and locations of mortises and holes for hardware.
7. Clearances and undercuts.
8. Doors to be factory finished and application requirements.

- C. Samples for Initial Selection: For factory-finished doors.
- D. Samples for Verification:
 - 1. Factory finishes applied to actual door face materials, approximately 8 by 10 inches (200 by 250 mm), for each material and finish. For each wood species and transparent finish, provide set of three Samples showing typical range of color and grain to be expected in finished Work.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For door inspector.
 - 1. Egress Door Inspector: Submit documentation of compliance with NFPA 101, Section 7.2.1.15.4.
 - 2. Submit copy of DHI's Fire and Egress Door Assembly Inspector (FDAI) certificate.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

- A. Special warranties.

1.05 QUALITY ASSURANCE

- A. Egress Door Inspector Qualifications: Inspector for field quality-control inspections of egress door assemblies complies with qualifications set forth in NFPA 101, Section 7.2.1.15.4 and the following:
 - 1. DHI's Fire and Egress Door Assembly Inspector (FDAI) certification.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with requirements of referenced standard and manufacturer's written instructions.
- B. Package doors individually in plastic bags or cardboard cartons.
- C. Mark each door on top and bottom rail with opening number used on Shop Drawings.

1.07 FIELD CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install doors until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and HVAC system is operating and maintaining

temperature and relative humidity at levels designed for building occupants for the remainder of construction period.

1.08 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace doors that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Delamination of veneer.
 - b. Warping (bow, cup, or twist) more than 1/4 inch (6.4 mm) in a 42-by-84-inch (1067-by-2134-mm) section.
 - c. Telegraphing of core construction in face veneers exceeding 0.01 inch in a 3-inch (0.25 mm in a 76.2-mm) span.
2. Warranty also includes installation and finishing that may be required due to repair or replacement of defective doors.
3. Warranty Period for Solid-Core Interior Doors: Life of installation.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Obtain flush wood doors from single manufacturer.

2.02 SOLID-CORE FIVE-PLY FLUSH WOOD VENEER-FACED DOORS AND TRANSOM PANELS FOR TRANSPARENT FINISH

A. Interior Doors, Solid-Core Five-Ply Veneer-Faced:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Lambton Doors.
 - b. Lynden Door, Inc.
 - c. Masonite Architectural.
 - d. VT Industries, Inc.
2. Performance Grade: ANSI/WDMA I.S. 1A Extra Heavy Duty.

3. Architectural Woodwork Standards Quality Grade: Premium.
4. Faces: Single-ply wood veneer not less than 1/50 inch (0.508 mm) thick.
 - a. Species: White oak or Walnut.
 - b. Cut: Plain sliced (flat sliced).
 - c. Match between Veneer Leaves: Slip match.
5. Exposed Vertical and Top Edges: Same species as faces or a compatible species - Architectural Woodwork Standards edge Type A.
6. Core for Non-Fire-Rated Doors:
 - a. Either glued wood stave or WDMA I.S. 10 structural composite lumber.
7. Construction: Five plies, hot-pressed bonded (vertical and horizontal edging is bonded to core), with entire unit abrasive planed before veneering.

2.03 FABRICATION

- A. Factory fit doors to suit frame-opening sizes indicated.
 1. Comply with clearance requirements of referenced quality standard for fitting unless otherwise indicated.
- B. Factory machine doors for hardware that is not surface applied.
 1. Locate hardware to comply with DHI-WDHS-3.
 2. Comply with final hardware schedules, door frame Shop Drawings, ANSI/BHMA-156.115-W, and hardware templates.
 3. Coordinate with hardware mortises in metal frames, to verify dimensions and alignment before factory machining.

2.04 FACTORY FINISHING

- A. Comply with referenced quality standard for factory finishing.
 1. Complete fabrication, including fitting doors for openings and machining for hardware that is not surface applied, before finishing.
 2. Finish faces, all four edges, edges of cutouts, and mortises.
 3. Stains and fillers may be omitted on top and bottom edges, edges of cutouts, and mortises.

- B. Factory finish doors.
- C. Transparent Finish:
 - 1. Architectural Woodwork Standards Grade: Premium.
 - a. System-5, Varnish, Conversion.
 - 2. Staining: Match plastic laminate finish on cabinets.
 - 3. Sheen: Satin.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine doors and installed door frames, with Installer present, before hanging doors.
 - 1. Verify that installed frames comply with indicated requirements for type, size, location, and swing characteristics and have been installed with level heads and plumb jambs.
 - 2. Reject doors with defects.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Hardware: For installation, see Section 08 71 00 "Door Hardware."
- B. Install doors to comply with manufacturer's written instructions and referenced quality standard, and as indicated.
- C. Job-Fitted Doors:
 - 1. Align and fit doors in frames with uniform clearances and bevels as indicated below.
 - a. Do not trim stiles and rails in excess of limits set by manufacturer or permitted for fire-rated doors.
 - 2. Machine doors for hardware.
 - 3. Seal edges of doors, edges of cutouts, and mortises after fitting and machining.
 - 4. Clearances:
 - a. Provide 1/8 inch (3.2 mm) at heads, jambs, and between pairs of doors.

- b. Provide 1/8 inch (3.2 mm) from bottom of door to top of decorative floor finish or covering unless otherwise indicated on Drawings.
 - c. Where threshold is shown or scheduled, provide 1/4 inch (6.4 mm) from bottom of door to top of threshold unless otherwise indicated.
 - d. Comply with NFPA 80 for fire-rated doors.
5. Bevel non-fire-rated doors 1/8 inch in 2 inches (3-1/2 degrees) at lock and hinge edges.

3.03 FIELD QUALITY CONTROL

- A. Inspection Agency: Engage a qualified inspector to perform inspections and to furnish reports to Engineer.
- B. Inspections:
 - 1. Egress Door Inspections: Inspect each door equipped with panic hardware, each door equipped with fire exit hardware, each door located in an exit enclosure, each electrically controlled egress door, and each door equipped with special locking arrangements in accordance with NFPA 101, Section 7.2.1.15.
- C. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- D. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.

3.04 ADJUSTING

- A. Operation: Rehang or replace doors that do not swing or operate freely.
- B. Finished Doors: Replace doors that are damaged or that do not comply with requirements. Doors may be repaired or refinished if Work complies with requirements and shows no evidence of repair or refinishing.

END OF SECTION

SECTION 08 16 13
FIBERGLASS DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Fiberglass Reinforced Polyester (FRP) doors and frames.

B. Related Requirements:

1. Section 08 71 00 "Door Hardware" for door hardware for FRP doors.

1.02 COORDINATION

- A. Coordinate requirements for installation of door hardware, electrified door hardware, and access control and security systems.

1.03 ACTION SUBMITTALS

- A. Product Data: Provide catalog cut of FRP door detailing internal construction and reinforcements, materials used and description of molding process.

B. Shop Drawings: Include the following:

1. Elevations of each door type.
2. Details of doors, including vertical- and horizontal-edge details and material thicknesses.
3. Frame details for each frame type, including dimensioned profiles and material thicknesses.
4. Locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.
6. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
7. Details of anchorages, joints, field splices, and connections.
8. Details of accessories.

- C. Samples for Initial Selection: Provide a complete set of available finish colors from the manufacturer for color selection upon request.
- D. Samples for Verification:
 - 1. Finishes: For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches (75 by 127 mm).

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver FRP doors and frames to jobsite in adequate crating with foam sheet separations between all components.
- B. Store FRP doors and frames indoors in a vertical position, clear of the floor, with blocking between the doors to permit air circulation between the doors and prevent damage to the door faces. Rain/water or condensation must not be allowed to collect or lay between stored doors. Do not wrap in plastic sheeting as it will promote condensation formation within. Permanent discoloration can result.
- C. Handle FRP doors and frames with care, to prevent damage to factory finishes. Wear protective gloves and do not slide or drag doors or frames against one another.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Chem-Pruf.
 - 2. Cline Doors.
 - 3. CORRIM Company.
 - 4. Edgewater FRP Doors.
 - 5. Special-Lite.
 - 6. Tiger Door.

2.02 FRP DOORS AND FRAMES

- A. Heavy Duty FRP Doors:
 - 1. Design: FRP doors shall be of seamless press-molded construction. Laminated FRP face sheets shall be applied while wet and uncured to an internal door stile and rail subframe/core assembly and then press-molded under heat and pressure. The

composite door panel must be integrally fused over its entire surface area, not just adhesive-bonded at perimeter stiles and rails. Doors shall remain under pressure during curing for flat, warp-free surfaces.

2. Stiles & Rails: A high-modulus pultruded FRP square or rectangular tube subframe is to be provided within the door.
 - a. Tubes are to be mitered and joined internally at the corners with solid polymer blocks to yield a one-piece unit that does not require any secondary external sealing.
 - b. Provide a tubular midrail across width of door at lock height, and additional horizontal rails where specific design conditions dictate.
 - c. Doors shall incorporate molded-in FRP edge strips, chemically bonded to the subframe stiles, for machining of hardware mortises so as not to cut or otherwise compromise the integrity of the pultruded stiles, nor allow moisture to penetrate into the core of the door.
 - d. All connections shall be chemically welded. No mechanical fasteners will be allowed.
 - e. The use or inclusion of aluminum, steel, gypsum or wood into stile and rail construction is not permitted.
3. Core: Triangular shaped 3/8-inch cell phenolic resin impregnated kraft paper honeycomb core shall be used. Molding pressure and resin gel time shall be sufficient to allow for penetration of resin into the cellular structure of the core to maximize shear and peel strengths at the skin/core interface and eliminate the possibility of delamination. Enclose honeycomb core completely within the stile and rail subframe.
 - a. Polypropylene plastic honeycomb core with a non-woven polyester veil and 2 lb. Polyisocyanurate Foam can be used. Use of balsa wood is not permitted.
4. Internal Reinforcement: High-modulus pultruded tubular FRP, high-density polymer compression blocks, or plastic compression blocking at all hardware locations, and corner locations. No wood blocking, steel or aluminum reinforcing plates, ribs or fittings shall be used. A minimum of 900 lbs of pullout strength is required for each factory supplied hinge screw.
5. Faces: Door facings shall utilize a chemical resistant thermosetting polyester resin system with fiber reinforcing layers. Supplier shall furnish door faces as shown on the drawings and in the door elevations. Chopped strand mat layers shall be used to provide bond integrity between gelcoat, laminated facings and the internal door structure. Structural reinforcement shall be in the form of a knitted multi-layer material with layers of uni-directional glass fiber oriented in both the vertical and horizontal directions for high stiffness, impact resistance and resistance to warping.

Gelcoat surface integrally molded to be 25/30 mils thick (wet) ultra-violet light stabilized marine grade NPG-isophthalic polyester gelcoat.

6. Finish: The exposed FRP door faces shall have a 3-4 mils (wet) factory applied two-part aliphatic polyurethane fully cured coating of industrial urethane. Coating shall have a minimum hardness of H to 2H. Finish shall be a slightly textured semi-gloss to minimize the visual effects of wear and tear.

- a. Color: To be selected by Engineer from manufacturer's full range.

B. FRP Frames:

1. Design: High-modulus pultruded structural FRP shape. The frame section shall be standard double rabbeted with integral doorstop, to match typical hollow metal configurations.
2. Corner Joints: Frame jambs and header shall be joined at corners via miter connections with hidden FRP angle clips and associated fasteners. Post and beam corners will not be acceptable.
3. Hardware Reinforcements: FRP reinforcing shall be chemically welded to door frame material at required locations. Minimum screw pullout strength of 1100 lb per #12 x 1-1/4" sheet metal screw is required. Mechanically fastened reinforcements are not permitted.
4. Anchors:
 - a. Bolt-In: Provide manufacturer's required number size, and type of stainless steel sleeve anchors for openings. Include extra anchors for additional frame height in two foot increments above 8'-0". Provide single bolt anchor at center of all headers over four feet in nominal width.
 - b. Grout-In: Provide manufacturer's required number of wire or strap type masonry anchors for installation into block wall. Fill frame cavity with grout.
5. Finish: Frames shall have a 3-4 mils (wet) factory applied two-part aliphatic polyurethane fully cured coating of industrial urethane. Industrial urethane chemical coating color topcoat, to match the color and sheen of the doors, for superior weatherability. Gelcoat may not be sprayed onto the frame as a secondary coating.
 - a. Color: To be selected by Engineer from manufacturer's full range.

2.03 FASTENERS

- A. All fasteners for all hardware shall be type 304 CRSS (18-8 series corrosion resistant stainless steel) with no exception. No carbon steel or aluminum components shall be used.

2.04 FABRICATION

- A. Hardware Preparation: Factory prepare FRP doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping in accordance with manufacturer, the Door Hardware Schedule, and templates.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Frames: Install in strict accordance with manufacturer's printed instructions. Set plumb and square, using shims for bolt-in of existing openings, or wood bracing prior to grouting of jambs. Use at least two 2x6 wood spreaders inside frame to maintain critical opening dimensions during grouting.
- B. Doors: Hang per manufacturer's printed instructions using special screws provided for hinge attachment. Install doors to swing freely and to stand open at any angle. After installation make final adjustments to hardware to allow for proper door operation and latching. All surface applied hardware shall be thru bolted.

END OF SECTION

SECTION 08 31 13

ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Access doors and frames in walls.

B. Related Requirements:

1. Section 07 72 00 "Roof Accessories" for roof hatches.
2. Section 05 53 00 "Metal Grating, Cover Plates, and Access Hatches" for doors installed in floors.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Samples: For each type of access door and frame and for each finish specified, complete assembly minimum 6 by 6 inches (150 by 150 mm) in size.

PART 2 - PRODUCTS

2.01 ACCESS DOORS AND FRAMES

A. Flush Access Doors with Exposed Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACUDOR Products, Inc.
 - b. Babcock-Davis.
 - c. J. L. Industries, Inc.; Activar Construction Products Group, Inc.
 - d. Karp Associates, Inc.
 - e. Larsen's Manufacturing Company.

- f. Milcor; Hart & Cooley, Inc.
 - g. Nystrom, Inc.
- 2. Description: Face of door flush with frame, with exposed flange and concealed hinge.
- 3. Optional Features: Masonry anchors.
- 4. Locations: Wall.
- 5. Door Size: Refer to Door Schedule on Drawings.
- 6. Metallic-Coated Steel Sheet for Door: Nominal 0.064 inch (1.63 mm), 16 gage, factory finished.
- 7. Frame Material: Same material, thickness, and finish as door.
- 8. Latch and Lock: Cam latch, screwdriver operated with interior release.

2.02 MATERIALS

- A. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- B. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.
- C. Frame Anchors: Same material as door face.
- D. Inserts, Bolts, and Anchor Fasteners: Hot-dip galvanized steel according to ASTM A153/A153M or ASTM F2329.

2.03 FABRICATION

- A. General: Provide access door and frame assemblies manufactured as integral units ready for installation.
- B. Metal Surfaces: For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.
- C. Doors and Frames: Grind exposed welds smooth and flush with adjacent surfaces. Furnish mounting holes, attachment devices and fasteners of type required to secure access doors to types of supports indicated.

2.04 FINISHES

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- D. Painted Finishes: Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - 1. Factory Finished: Apply manufacturer's standard baked-enamel or powder-coat finish immediately after cleaning and pretreating, with minimum dry-film thickness of 1 mil (0.025 mm) for topcoat.
 - a. Color: As selected by Engineer from full range of industry colors.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Comply with manufacturer's written instructions for installing access doors and frames.

3.03 ADJUSTING

- A. Adjust doors and hardware, after installation, for proper operation.
- B. Frames: Install in strict accordance with manufacturer's printed instructions. Set plumb and square, using shims for bolt-in of existing openings, or wood bracing prior to grouting of jambs. Use at least two 2x6 wood spreaders inside frame to maintain critical opening dimensions during grouting.
- C. Doors: Hang per manufacturer's printed instructions using special screws provided for hinge attachment. Install doors to swing freely and to stand open at any angle. After installation make final adjustments to hardware to allow for proper door operation and latching. All surface applied hardware shall be thru bolted.

END OF SECTION

SECTION 08 33 13
COILING COUNTER DOORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Fire-rated counter door assemblies.

1.02 ACTION SUBMITTALS

A. Product Data: For each type and size of coiling counter door and accessory.

1. Include construction details, material descriptions, dimensions of individual components, profiles for slats, and finishes.
2. Include rated capacities, operating characteristics, and furnished accessories.
3. Include description of automatic closing device and testing and resetting instructions.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies, and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include points of attachment and their corresponding static and dynamic loads imposed on structure.
4. Show locations of controls, locking devices, detectors or replaceable fusible links, and other accessories.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1. Fire-Rated Door Inspector: Submit documentation of compliance with NFPA 80, section 5.2.3.1.
2. Submit copy of DHI Fire and Egress Door Assembly Inspector (FDAI) certificate.

1.04 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For coiling counter doors to include in maintenance manuals.
- B. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer for both installation and maintenance of units required for this Project.
- B. Fire-Rated Door Inspector Qualifications: Inspector for field quality control inspections of fire-rated door assemblies is to meet the qualifications set forth in NFPA 80, section 5.2.3.1 and the following:
 - 1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain coiling counter doors from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Fire-Rated Door Assemblies: Complying with NFPA 80; listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 or UL 10B.

2.03 FIRE-RATED COUNTER DOOR ASSEMBLY

- A. Fire-Rated Counter Door: Overhead fire-rated coiling door formed with curtain of interlocking metal slats.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C.H.I. Overhead Doors, Inc.
 - b. Clopay Building Products.
 - c. Cookson; a CornellCookson company.
 - d. Cornell; a CornellCookson company.

- e. McKeon Door Company.
 - B. Operation Cycles: Door components and operators capable of operating for not less than 20,000. One operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.
 - 1. Include tamperproof cycle counter.
 - C. Fire Rating: 3 hours.
 - D. Door Curtain Material: Stainless steel.
 - E. Door Curtain Slats: Flat profile slats of 1-1/2-inch (38-mm) center-to-center height.
 - F. Curtain Jamb Guides: Stainless steel with exposed finish matching curtain slats.
 - G. Hood: Stainless steel.
 - 1. Shape: As indicated on Drawings.
 - 2. Mounting: Face of wall.
 - H. Sill Configuration: No sill.
 - I. Manual Door Operator: Push-up operation.
 - J. Door Finish:
 - 1. Stainless Steel Finish: ASTM A480/A480M No. 4 (polished directional satin).
- 2.04 MATERIALS, GENERAL
- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.05 DOOR CURTAIN MATERIALS AND FABRICATION
- A. Door Curtains: Fabricate coiling counter door curtain of interlocking metal slats in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:
 - 1. Stainless Steel Door Curtain Slats: ASTM A240/A240M or ASTM A666, Type 304; sheet thickness of 0.025 inch (0.64 mm); and as required.
 - B. Curtain Jamb Guides: Manufacturer's standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading.

Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain.

2.06 HOODS

- A. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.
 - 1. Stainless Steel: 0.025-inch- (0.64-mm-) thick, stainless steel sheet, Type 304, complying with ASTM A240/A240M or ASTM A666.
 - 2. Include automatic drop baffle on fire-rated doors to guard against passage of smoke or flame.

2.07 CURTAIN ACCESSORIES

- A. Push/Pull Handles: Equip each push-up-operated or emergency-operated door with lifting handles on each side of door, finished to match door.
- B. Automatic-Closing Device: Equip each fire-rated door with an automatic-closing device or holder-release mechanism and governor unit complying with NFPA 80 and an easily tested and reset release mechanism. Testing for manually operated doors allows resetting by opening the door without retensioning the counterbalance mechanism. Automatic-closing device is to be designed for activation by the following:
 - 1. Replaceable fusible links with temperature rise and melting point of 165 deg F (74 deg C) interconnected and mounted on both sides of door opening.

2.08 COUNTERBALANCE MECHANISM

- A. General: Counterbalance doors by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
- B. Counterbalance Barrel: Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 in./ft. (2.5 mm/m) of span under full load.
- C. Counterbalance Spring: One or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.

1. Fire-Rated Doors: Equip with auxiliary counterbalance spring and prevent tension release from main counterbalance spring when automatic closing device operates.
 - D. Torsion Rod for Counterbalance Shaft: Fabricate of manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.
 - E. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.
- 2.09 MANUAL DOOR OPERATORS
- A. General: Equip door with manual door operator by door manufacturer.
 - B. Push-up Door Operation: Design counterbalance mechanism so that required lift or pull for door operation does not exceed 25 lbf (111 N).
- 2.10 GENERAL FINISH REQUIREMENTS
- A. Comply with NAAMM/NOMMA 500 for recommendations for applying and designating finishes.
 - B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- 2.11 STAINLESS STEEL FINISHES
- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 1. Run grain of directional finishes with long dimension of each piece.
 2. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 3. Directional Satin Finish: ASTM A480/A480M No. 4.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates areas and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Install coiling counter doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.
- B. Install coiling counter doors, hoods, controls, and operators at the mounting locations indicated for each door.
- C. Fire-Rated Doors: Install according to NFPA 80.

3.03 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, section 5.2.
- B. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- C. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.
- D. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in NFPA 80.

3.04 ADJUSTING

- A. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.
- B. Lubricate bearings and sliding parts as recommended by manufacturer.
- C. Adjust seals to provide tight fit around entire perimeter.

3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain coiling counter doors.

END OF SECTION

SECTION 08 33 23
OVERHEAD COILING DOORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Insulated service doors.
2. Fire-rated service doors.

B. Related Requirements:

1. Section 05 50 00 "Metal Fabrications" for miscellaneous steel supports, door-opening framing, corner guards, and bollards.

1.02 ACTION SUBMITTALS

A. Product Data: For each type and size of overhead coiling door and accessory.

1. Include construction details, material descriptions, dimensions of individual components, profiles for slats, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.
3. Include description of automatic-closing device and testing and resetting instructions.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies, and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include points of attachment and their corresponding static and dynamic loads imposed on structure.
4. For exterior components, include details of provisions for assembly expansion and contraction and for excluding and draining moisture to the exterior.

5. Show locations of controls, locking devices, detectors or replaceable fusible links, and other accessories.
 6. Include diagrams for power, signal, and control wiring.
- C. Samples for Verification: For each type of exposed finish on the following components, in manufacturer's standard sizes:
1. Curtain slats.
 2. Locking device(s).
 3. Include similar Samples of accessories involving color selection.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing and inspecting agency.
1. Fire-Rated Door Inspector: Submit documentation of compliance with NFPA 80, Section 5.2.3.1.
 2. Submit copy of DHI Fire and Egress Door Assembly Inspector (FDAI) certificate.
- B. Oversize Construction Certification: For door assemblies required to be fire-rated and that exceed size limitations of labeled assemblies.
- C. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

- A. Special warranty.
- B. Maintenance Data: For overhead coiling doors to include in maintenance manuals.
- C. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer for both installation and maintenance of units required for this Project.
- B. Fire-Rated Door Inspector Qualifications: Inspector for field quality control inspections of fire-rated door assemblies is to meet the qualifications set forth in NFPA 80, Section 5.2.3.1 and the following:
1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.

1.06 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of doors that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain overhead coiling doors from single source from single manufacturer.

- 1. Obtain operators and controls from overhead coiling-door manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Fire-Rated Door Assemblies: Complying with NFPA 80; listed and labeled by qualified testing agency, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 or UL 10B.

- 1. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.

- B. Structural Performance, Exterior Doors: Capable of withstanding the following design wind loads:

- 1. Design Wind Load: As indicated on Drawings.
 - 2. Testing: According to ASTM E330/E330M.
 - 3. Deflection Limits: Design overhead coiling doors to withstand design wind load without evidencing permanent deformation or disengagement of door components.
 - 4. Operability under Wind Load: Design overhead coiling doors to remain operable under uniform pressure (velocity pressure) of 20-lbf/sq. ft. (960-Pa) wind load, acting inward and outward.

- C. Seismic Performance: Overhead coiling doors are to withstand the effects of earthquake motions determined according to ASCE/SEI 7.

- 1. Component Importance Factor: 1.0.

2.03 DOOR ASSEMBLY

- A. Insulated Service Door: Overhead coiling door formed with curtain of interlocking metal slats.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation; RapidSlat Model 626 Stormtite or a comparable product by one of the following:
 - a. C.H.I. Overhead Doors, Inc.
 - b. Clopay Building Products.
 - c. Cookson; a CornellCookson company.
- B. Operation Cycles: Door components and operators capable of operating for not less than 20,000. One operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.
- C. Air Infiltration: Maximum rate of 1.0 cfm/sq. ft. (5.1 L/s per sq. m) at 15 and 25 mph (24.1 and 40.2 km/h) when tested according to ASTM E283.
- D. Insulated Door Curtain R-Value: 7.7 deg F x h x sq. ft./Btu.
- E. Insulated Door Assembly U-Factor: 0.13 Btu/deg F x h x sq. ft.
- F. Door Curtain Material: Galvanized steel.
- G. Door Curtain Slats: Flat profile slats of 2-5/8-inch (67-mm) center-to-center height.
 - 1. Insulated-Slat Interior Facing: Metal.
 - 2. Gasket Seal. Manufacturer's standard continuous gaskets between slats.
- H. Bottom Bar: Two angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch (38 by 38 by 3 mm) thick; fabricated from stainless steel.
- I. Curtain Jamb Guides: Galvanized steel with exposed finish matching curtain slats.
- J. Hood: Galvanized steel.
 - 1. Shape: As indicated on Drawings.
 - 2. Mounting: Face of wall.
- K. Locking Devices: Equip door with locking device assembly and chain lock keeper.
 - 1. Locking Device Assembly: Single-jamb side locking bars, operable from.

L. Electric Door Operator:

1. Usage Classification: Light duty, up to 10 cycles per hour.
2. Safety: Listed according to UL 325 by a qualified testing agency for commercial or industrial use; moving parts of operator enclosed or guarded if exposed and mounted at 8 ft. (2.44 m) or lower.
3. Motor Exposure: Exterior, wet, and humid.
4. Motor Electrical Characteristics:
 - a. Horsepower: As required by manufacturer based on door size.
 - b. Voltage: 480V AC, 3-phase.
5. Emergency Manual Operation: Chain type.
6. Obstruction-Detection Device: Automatic photoelectric sensor.
7. Control Station(s): Interior mounted.

M. Curtain Accessories: Equip door with weatherseals.

N. Door Finish:

1. Baked-Enamel or Powder-Coated Finish: Color as selected by Engineer from manufacturer's full range.

2.04 FIRE-RATED DOOR ASSEMBLY

A. Fire-Rated Service Door: Overhead fire-rated coiling door formed with curtain of interlocking metal slats.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation; Model 630 or a comparable product by one of the following:
 - a. C.H.I. Overhead Doors, Inc.
 - b. Clopay Building Products.
 - c. Cornell; a CornellCookson company.

B. Operation Cycles: Door components and operators capable of operating for not less than 20,000. One operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.

C. Fire Rating: 3 hours.

- D. Door Curtain Material: Galvanized steel.
- E. Door Curtain Slats: Flat profile slats of 2-5/8-inch (67-mm) center-to-center height.
- F. Bottom Bar: Two angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch (38 by 38 by 3 mm) thick; fabricated from stainless steel.
- G. Curtain Jamb Guides: Stainless steel with exposed finish matching curtain slats.
- H. Hood: Match curtain material and finish.
 - 1. Mounting: Face of wall.
- I. Locking Devices: Equip door with locking device assembly.
 - 1. Locking Device Assembly: Single-jamb side locking bars, operable from inside with thumbturn.
- J. Manual Door Operator: Chain-hoist operator.
- K. Curtain Accessories: Equip door with smoke seals, automatic-closing device and push/pull handles.
- L. Door Finish:
 - 1. Baked-Enamel or Powder-Coated Finish: Color as selected by Engineer from manufacturer's full range.

2.05 MATERIALS, GENERAL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.06 DOOR CURTAIN MATERIALS AND CONSTRUCTION

- A. Door Curtains: Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:
 - 1. Steel Door Curtain Slats: Zinc-coated (galvanized), cold-rolled structural-steel sheet; complying with ASTM A653/A653M, with G90 (Z275) zinc coating; nominal sheet thickness (coated) of 0.028 inch (0.71 mm); and as required.
 - 2. Stainless Steel Door Curtain Slats: ASTM A240/A240M or ASTM A666, Type 304; sheet thickness of 0.025 inch (0.64 mm); and as required.

3. Insulation: Fill slats for insulated doors with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E84 or UL 723. Enclose insulation completely within slat faces.
 4. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face, with minimum steel thickness of 0.010 inch (0.25 mm).
- B. Curtain Jamb Guides: Manufacturer's standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain, and a continuous bar for holding windlocks.

2.07 HOODS

- A. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.
1. Galvanized Steel: Nominal 0.028-inch- (0.71-mm-) thick, hot-dip galvanized-steel sheet with G90 (Z275) zinc coating, complying with ASTM A653/A653M.
 2. Stainless Steel: 0.025-inch- (0.64-mm-) thick, stainless steel sheet, Type 304, complying with ASTM A240/A240M or ASTM A666.
 3. Include automatic drop baffle on fire-rated doors to guard against passage of smoke or flame.
 4. Exterior-Mounted Doors: Fabricate hood to act as weather protection and with a perimeter sealant-joint-bead profile for applying joint sealant.
- B. Removable Metal Soffit: Formed or extruded from same metal and with same finish as curtain if hood is mounted above ceiling unless otherwise indicated.

2.08 LOCKING DEVICES

- A. Slide Bolt: Fabricate with side-locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.
- B. Locking Device Assembly: Fabricate with cylinder lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bars to engage through slots in tracks.
- C. Chain Lock Keeper: Suitable for padlock.

- D. Safety Interlock Switch: Equip power-operated doors with safety interlock switch to disengage power supply when door is locked.

2.09 CURTAIN ACCESSORIES

- A. Smoke Seals: Equip each fire-rated door with replaceable smoke-seal perimeter gaskets or brushes for smoke and draft control as required for door listing and labeling by a qualified testing agency.
- B. Weatherseals for Exterior Doors: Equip each exterior door with weather-stripping gaskets fitted to entire exterior perimeter of door for a weather-resistant installation unless otherwise indicated.
 - 1. At door head, use 1/8-inch- (3-mm-) thick, replaceable, continuous-sheet baffle secured to inside of hood or field-installed on the header.
 - 2. At door jambs, use replaceable, adjustable, continuous, flexible, 1/8-inch- (3-mm-) thick seals of flexible rubber or neoprene.
- C. Automatic-Closing Device: Equip each fire-rated door with an automatic-closing device or holder-release mechanism and governor unit complying with NFPA 80 and an easily tested and reset release mechanism. Testing for manually operated doors allows resetting by opening the door without retensioning the counterbalance mechanism. Automatic-closing device is to be designed for activation by the following:
 - 1. Replaceable fusible links with temperature rise and melting point of 165 deg F (74 deg C) interconnected and mounted on both sides of door opening.

2.10 COUNTERBALANCE MECHANISM

- A. General: Counterbalance doors by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
- B. Counterbalance Barrel: Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 in./ft. (2.5 mm/m) of span under full load.
- C. Counterbalance Spring: One or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.
 - 1. Fire-Rated Doors: Equip with auxiliary counterbalance spring and prevent tension release from main counterbalance spring when automatic-closing device operates.

- D. Torsion Rod for Counterbalance Shaft: Fabricate of manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.
- E. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.

2.11 MANUAL DOOR OPERATORS

- A. General: Equip door with manual door operator by door manufacturer.
- B. Chain-Hoist Operator: Consisting of endless steel hand chain, chain-pocket wheel and guard, and gear-reduction unit with a maximum 25-lbf (111-N) force for door operation. Provide alloy-steel hand chain with chain holder secured to operator guide.

2.12 ELECTRIC DOOR OPERATORS

- A. General: Electric door operator assembly of size and capacity recommended and provided by door manufacturer for door and operation-cycles requirement specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, control stations, control devices, integral gearing for locking door, and accessories required for proper operation.
 - 1. Comply with NFPA 70.
 - 2. Control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24-V ac or dc.
- B. Usage Classification: Electric operator and components capable of operating for not less than number of cycles per hour indicated for each door.
- C. Door Operator Location(s): Operator location indicated for each door.
 - 1. Top-of-Hood Mounted: Operator is mounted to the right or left door head plate with the operator on top of the door-hood assembly and connected to the door drive shaft with drive chain and sprockets. Headroom is required for this type of mounting.
- D. Motors: Reversible-type motor for motor exposure indicated for each door assembly.
 - 1. Electrical Characteristics: Minimum as indicated for each door assembly. If not indicated, large enough to start, accelerate, and operate door in either direction from any position, at a speed not less than 8 in./sec. (203 mm/s) and not more than 12 in./sec. (305 mm/s), without exceeding nameplate ratings or service factor.
 - 2. Operating Controls, Controllers, Disconnect Switches, Wiring Devices, and Wiring: Manufacturer's standard unless otherwise indicated.
 - 3. Coordinate wiring requirements and electrical characteristics of motors and other electrical devices with building electrical system and each location where installed.

- E. Limit Switches: Equip each motorized door with adjustable switches interlocked with motor controls and set to automatically stop door at fully opened and fully closed positions.
- F. Obstruction-Detection Devices: External entrapment protection consisting of indicated automatic safety sensor capable of protecting full width of door opening. For non-fire-rated doors, activation of device immediately stops and reverses downward door travel. For fire-rated doors, activation delays closing.
 - 1. Photoelectric Sensor: Manufacturer's standard system designed to detect an obstruction in door opening without contact between door and obstruction.
- G. Control Station: Three-button control station in fixed location with momentary-contact push-button controls labeled "Open" and "Stop" and sustained- or constant-pressure push-button control labeled "Close."
 - 1. Exterior-Rated Units: Full-guarded, standard-duty, surface-mounted, weatherproof type, NEMA ICS 6, Type 4 enclosure, key operated.
- H. Emergency Manual Operation: Equip each electrically powered door with capability for emergency manual operation. Design manual mechanism so required force for door operation does not exceed 25 lbf (111 N).
- I. Emergency Operation Disconnect Device: Equip operator with hand-operated disconnect mechanism for automatically engaging manual operator and releasing brake for emergency manual operation while disconnecting motor without affecting timing of limit switch. Mount mechanism so it is accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.
- J. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.

2.13 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM/NOMMA 500 for recommendations for applying and designating finishes.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.14 STEEL AND GALVANIZED-STEEL FINISHES

- A. Factory Prime Finish: Manufacturer's standard primer, compatible with field-applied finish. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.

- B. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.

2.15 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Bright, Cold-Rolled, Unpolished Finish: ASTM A480/A480M No. 2B.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates areas and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.
- B. Examine locations of electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.
- B. Install overhead coiling doors, hoods, controls, and operators at the mounting locations indicated for each door.
- C. Accessibility: Install overhead coiling doors, switches, and controls along accessible routes in compliance with the accessibility standard.
- D. Fire-Rated Doors: Install according to NFPA 80.
- E. Power-Operated Doors: Install according to UL 325.

3.03 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and to furnish reports to Engineer.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test door release, closing, and alarm operations when activated by smoke detector or building's fire-alarm system. Test manual operation of closed door. Reset door-closing mechanism after successful test.
 2. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, Section 5.2.
- C. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- D. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.
- E. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in NFPA 80.

3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. After electrical circuitry has been energized, operate doors to confirm proper motor rotation and door performance.
 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

3.05 ADJUSTING

- A. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.
1. Adjust exterior doors and components to be weather resistant.
- B. Lubricate bearings and sliding parts as recommended by manufacturer.
- C. Adjust seals to provide tight fit around entire perimeter.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain overhead coiling doors.

END OF SECTION

SECTION 08 34 19
INDUSTRIAL SWING DOORS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section include paired, monorail, industrial swing doors.

1.02 ACTION SUBMITTALS

- A. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation instructions.
- B. Shop Drawings: Provide shop drawings showing layout, profiles, and product components, including anchorage, hardware, and finishes. Include dimensional plans, applicable material specifications, elevations and sections detailing mounting and connections.
- C. Calculations: Upon signed finalization and approval of dimensions, mounting location material and configuration, and load requirements;
 - 1. Submit stamped calculations by a registered professional engineer from within the state or territory where the project will be constructed or substantially improved, to verify the door's ability to withstand the design loading.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer and welder.
- B. Manufacturer's Certificates: Certify products meet or exceed specified requirements.

1.04 CLOSEOUT SUBMITTALS

- A. Provide Operation and Maintenance data to include methods for maintaining installed products, precautions against cleaning materials and methods detrimental to finishes and performance.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer must demonstrate a minimum of five years successful experience in design and manufacture of similar related closures. Upon request,

provide supporting evidence including list of installations, descriptions, name, and method of contact.

- B. Welder Qualifications: Welders Certified in accordance with American Welding Society Procedures: AWS-1-GMAW-S, WPS No. B2.004.90 for applicable material used in production of specified product.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging container with identification labels intact until ready for installation.
- B. Protect materials from exposure to moisture.
- C. Store materials in a dry, warm, ventilated, weather-tight location. If outdoor storage is required, block materials to store at an incline, to prevent pooling of any moisture and promote runoff. Tarp materials in a tent-like arrangement, elevated above the product with open sides to allow airflow. Store all other hardware in a dry controlled environment.
- D. Use caution when unloading and handling product to avoid bending, denting, crushing, or other damage to the product.
- E. When using forklifts, use forks of proper length to fully support product being moved. Consult shop drawings or consult with factory for proper lift points.

1.07 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.08 COORDINATION

- A. Coordinate work with other operations and installation of adjacent materials to avoid damage.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with the requirements, provide Monorail Door by PS Access Solutions or comparable product from one of the following:
 - 1. HMF Express.
 - 2. Fleming Steel Door Company.

2.02 DOORS AND FRAMES

- A. Door Sections: Sections shall be, at a minimum, nominal 1-5/8 inch thick, fabricated with a welded internal frame, 16 gauge sheeting on the interior and exterior, welded in place. Insulate voids between internal door framing and door sheeting, full depth of cavity.
- B. Frame: Frames shall be fabricated from formed steel shapes and sized as shown on the drawings. Provide anchor preps as indicated on the drawings, or embedment ties where the frames will be integral to the wall. Threshold to be of custom design, fabricated from 12 gauge 304-2B stainless steel, and factory welded to frame. Prepare threshold for countersunk anchors at 14 inch centers maximum.
- C. Hinges: Sized to the requirements of the door, but at a minimum: Pintles of 3/8" diameter, 3/16" thick mounting flanges and barrel. Provide a minimum of three (3) hinges per jamb on doors up to 8 ft. high, four (4) hinges up to 12 ft. high, five (5) hinges up to 16 ft. high. Hinges shall be furnished with thrust bearings and grease fittings. Hinges to be prepped for jamb mounting by bolting or welding.
- D. Latching: Latch to be single point, gravity type bar latch. Latch to be lever operated from both sides of door. Provide beveled strike and keeper for automatic latching. Finish on latch to be gray enamel. See Options for additional latching information.
- E. Weatherseals: Seals at head, jambs, and sill to be nylon filament brush in a mill finish aluminum retainer.
- F. Include Monorail Notches, sized to requirements, with weatherseals to match.

2.03 MATERIALS

- A. Industrial Swing Door Panel:
 - 1. Steel: Structural or formed steel shapes conforming to ASTM A 36; tubing conforming to ASTM A 500 Grade B, ASTM A 513; bars conforming to ASTM A 36, M1020; of appropriate size and strength with welded construction.
- B. Door Panel Sheeting: Panel to be sheeted with galvanealed steel sheeting or plate, Commercial Quality-Low Carbon ASTM-A-569, ASTM-A-366, ASTM-A-36 welded in place. Optional materials include Stainless Steel (304 or 316).
 - 1. Steel: Commercial Quality-Low Carbon steel conforming to ASTM A 569, ASTM A 366, ASTM A 36; of appropriate size and strength with welded construction.
- C. Weatherseals to be compressible rubber type or brush, typically EPDM and Nylon Brush Seal unless otherwise noted, and to be field replaceable.
- D. Frame: To include jamb and head members for field locating and installation on structure. Jamb members to be designed and fabricated with appropriate material as required for the loading.

1. Steel: Structural or formed steel shapes conforming to ASTM A 36 of appropriate size and strength.
- E. Frame Mounting Hardware: Provide anchors, as required.
- F. Operating Hardware: Provide hardware sized for the size and weight of the industrial sliding door. Hardware to be factory located as practical. Latching hardware to be as indicated on Drawings. Doors to be factory prepared for applicable latching devices.
- G. Steel Shop Finish: Apply in accordance with manufacturer recommendations and instructions.
 1. Primer: One shop coat of manufacturer's standard shop primer (S-W Kemflash Primer E61-R-26).
 2. Topcoat: One shop coat of Standard Industrial Enamel (S-W Industrial Coatings B54 Series)
 3. Color: As selected by the Engineer from the full range.

2.04 FABRICATION

- A. Fit and shop assemble items in largest practical sections, for delivery to site.
- B. Fabricate items with joints tightly fitted and secured.
- C. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Engineer of unsatisfactory preparation before proceeding.

3.02 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's installations instructions, approved shop drawings, shipping, handling, and storage instructions, and product carton instructions for installation.

END OF SECTION

SECTION 08 34 73.13

METAL SOUND CONTROL DOOR ASSEMBLIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes metal sound control door assemblies.

1.02 COORDINATION

- A. Coordinate installation of anchorages for sound control door assemblies. Furnish setting drawings, templates, and directions for installing anchorages. Deliver sleeves, inserts, anchor bolts, and items with integral anchors to Project site in time for installation.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include sound ratings, construction details, material descriptions, core descriptions, and finishes.
- B. Shop Drawings: For sound control door assemblies.
 - 1. Include elevations of each door design.
 - 2. Include details of sound control seals, door bottoms, and thresholds.
 - 3. Include details of doors, including vertical- and horizontal-edge details and metal thicknesses.
 - 4. Include frame details for each frame type, including dimensioned profiles and metal thicknesses.
 - 5. Include locations of reinforcements and preparations for hardware.
 - 6. Include details of each different wall opening condition.
 - 7. Include details of anchorages, joints, field splices, and connections.
 - 8. Include details of accessories.
 - 9. Include details of conduits and preparations for power, signal, and control systems.
- C. Schedule: Provide a schedule of sound control door assemblies prepared using same reference numbers for details and openings as those on Drawings. Coordinate with the Door Hardware Schedule.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and manufacturer.
- B. Product Certificates: For each type of sound control door assembly.
- C. Product Test Reports: For each sound control door assembly, for tests performed by a qualified testing agency.
- D. Sample Warranty: For manufacturer's special warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sound control door assemblies to include in maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver doors and frames palletized, wrapped, or crated to provide protection during transit and Project-site storage. Avoid the use of nonvented plastic.
 - 1. Provide additional protection to prevent damage to factory-finished units.
- B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
- C. Store doors and frames vertically under cover at Project site with head up. Place on minimum 4-inch- (102-mm-) high wood blocking. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

1.08 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of sound control door assemblies that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure to meet sound rating requirements.
 - b. Faulty operation of sound seals.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use or weathering.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Sound Rating: Provide sound control door assemblies identical to those of assemblies tested as sound-retardant units by an acoustical testing agency, and have the following minimum rating:
 - 1. STC Rating: 52 as calculated by ASTM E413 when tested in an operable condition according to ASTM E90.
- B. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.

2.02 STEEL SOUND CONTROL DOORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AMBICO Limited.
 - 2. IAC Acoustics.
 - 3. Krieger Specialty Products Company.
 - 4. Noise Barriers, LLC.
 - 5. Overly Door Company.
- B. Source Limitations: Obtain steel sound control door assemblies, including doors, frames, sound control seals, hinges, thresholds, and other items essential for sound control, from single source from single manufacturer.
- C. Doors: Flush-design sound control doors, 1.875 inches (48 mm) thick, of seamless construction; with manufacturer's standard sound-retardant core as required to provide STC and fire rating indicated. Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges. Fabricate according to NAAMM-HMMA 865.
 - 1. Exterior Doors: Fabricate from metallic-coated steel sheet 0.052-inch (1.32-mm) nominal thickness or thicker as required to provide STC rating indicated.
 - 2. Interior Doors: Fabricate from cold-rolled steel sheet unless otherwise indicated, 0.048-inch (1.21-mm) nominal thickness or thicker as required to achieve STC rating indicated.
 - 3. Core: Manufacturer's standard sound control core.

4. Top and Bottom Channels: Closed with continuous channels of same material as face sheets, spot welded to face sheets not more than 6 inches (152 mm) o.c.
5. Hardware Reinforcement: Same material as face sheets.

D. Materials:

1. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
2. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B, with G60 (Z180) zinc (galvanized) or A40 (ZF120) zinc-iron-alloy (galvannealed) coating designation.

E. Finishes:

1. Factory-Applied Paint Finish: Manufacturer's standard primer and finish coats, complying with SDI A250.3 for performance and acceptance criteria.
2. Color and Gloss: For exterior doors, match finish color and gloss specified in Section 08 41 13 "Aluminum-Framed Entrances and Storefronts." For interior doors, color as selected by Architect.

2.03 SOUND CONTROL FRAMES

A. Frames: Fabricate sound control door frames with corners mitered, reinforced, and continuously welded the full depth and width of frame. Fabricate according to NAAMM-HMMA 865.

1. Weld frames according to NAAMM-HMMA 820.
2. Exterior Frames: Fabricate from metallic-coated steel sheet 0.079-inch (2.01-mm) nominal thickness or thicker as required to provide STC rating indicated.
3. Interior Frames: Fabricate from cold-rolled steel sheet unless otherwise indicated, 0.075-inch (1.90-mm) nominal thickness or thicker as required to provide STC rating indicated.
4. Hardware Reinforcement: Fabricate according to NAAMM-HMMA 865 of same material as face sheets.
5. Head Reinforcement: Metallic-coated steel channel or angle stiffener, 0.108-inch (2.74-mm) nominal thickness.
6. Jamb Anchors:
 - a. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.064-inch (1.63-mm) nominal-thickness metallic-coated steel with corrugated or perforated straps not less than 2 inches (51 mm) wide

by 10 inches (254 mm) long; or wire anchors not less than 0.156 inch (3.9 mm) thick.

- b. Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter, metallic-coated steel bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.
- 7. Floor Anchors: Not less than 0.079-inch (2.01-mm) nominal-thickness metallic-coated steel, and as follows:
 - a. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
 - 8. Ceiling Struts: Minimum 3/8-inch-thick by 2-inch- (9.5-mm-thick by 51-mm-) wide uncoated steel unless otherwise indicated.

B. Materials:

- 1. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
- 2. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B, with G60 (Z180) zinc (galvanized) or A40 (ZF120) zinc-iron-alloy (galvannealed) coating designation.
- 3. Supports and Anchors: After fabricating, galvanize units to be built into exterior walls according to ASTM A153/A153M, Class B.
- 4. Inserts, Bolts, and Fasteners: Provide items to be built into exterior walls, hot-dip galvanized according to ASTM A153/A153M or ASTM F2329.
- 5. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching sound control door frames of type indicated.
- 6. Mineral-Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers.

C. Finishes:

- 1. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 - a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

2.04 HARDWARE

- A. Sound Control Door Hardware: Manufacturer's standard sound control system, including head and jamb seals, door bottoms, cam-lift hinges, and thresholds, as required by testing to achieve STC and fire rating indicated.
 - 1. Head and Jamb Seals:
 - a. Magnetic Seals: One-piece units consisting of closed-cell sponge neoprene seal and resiliently mounted magnet held in place by metal retainer, with retainer cover of same material as door frame; attached to door frame with concealed screws.
 - 2. Automatic Door Bottoms: Neoprene or silicone gasket, held in place by metal housing, that automatically drops to form seal when door is closed; mounted to bottom edge of door with screws.
 - a. Mounting: Mortised or semimortised into bottom of door as required by testing to achieve STC rating indicated.
 - 3. Cam-Lift Hinges: Full-mortise template type that raises door 1/2 inch (13 mm) when door is fully open; with hardened pin; fabricated from stainless steel.
 - 4. Thresholds: Flat, smooth, unfluted type as recommended by manufacturer; fabricated from stainless steel.
- B. Other Hardware: Comply with requirements in Section 08 71 00 "Door Hardware."

2.05 FABRICATION

- A. Steel Sound Control Door Fabrication: Sound control doors to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal.
 - 1. Comply with requirements in NFPA 80 for fire-rated doors.
 - 2. Seamless Edge Construction: Fabricate doors with faces joined at vertical edges by welding; welds shall be ground, filled, and dressed to make them invisible and to provide a smooth, flush surface.
 - 3. Exterior Doors: Close top edges flush and seal joints against water penetration. Provide weep-hole openings in bottom of exterior doors to permit moisture to escape.
 - 4. Hardware Preparation: Factory prepare sound control doors to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping.

- a. Reinforce doors to receive nontemplated mortised and surface-mounted door hardware.
 - b. Locate door hardware as indicated, or if not indicated, according to NAAMM-HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
- 5. Tolerances: Fabricate doors to tolerances indicated in NAAMM-HMMA 865.
- B. Sound Control Frame Fabrication: Fabricate sound control frames to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
 - 1. Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible. Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated from same thickness metal as frames.
 - 2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - 3. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
 - 4. Jamb Anchors: Provide number and spacing of anchors as follows:
 - a. Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
 - (1) Two anchors per jamb up to 60 inches (1524 mm) in height.
 - (2) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) in height.
 - (3) Four anchors per jamb from 90 to 96 inches (2286 to 2438 mm) in height.
 - (4) Four anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm), or fraction thereof, more than 96 inches (2438 mm) in height.
 - b. Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.

5. Head Reinforcement: For grouted frames more than 48 inches (1219 mm) wide, weld continuous head reinforcement to back of frame at head full width of opening.
6. Hardware Preparation: Factory prepare sound control frames to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping.
 - a. Reinforce frames to receive nontemplated mortised and surface-mounted door hardware.
 - b. Locate hardware as indicated, or if not indicated, according to NAAMM-HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
7. Tolerances: Fabricate frames to tolerances indicated in NAAMM-HMMA 865.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of sound control door frame connections before frame installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.
- B. Prior to installation, adjust and securely brace sound control door frames to the following tolerances:
 1. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 2. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 3. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 4. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.

- C. Drill and tap doors and frames to receive nontemplated mortised and surface-mounted door hardware.

3.03 INSTALLATION

- A. General: Install sound control door assemblies plumb, rigid, properly aligned, and securely fastened in place; comply with manufacturer's written instructions.
- B. Frames: Install sound control door frames in sizes and profiles indicated.
 - 1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
 - a. At fire-rated openings, install frames according to NFPA 80.
 - b. Where frames are fabricated in sections due to shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, and dress; make splice smooth, flush, and invisible on exposed faces.
 - c. Remove temporary braces only after frames or bucks have been properly set and secured.
 - d. Check squareness, twist, and plumbness of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
 - 2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.
 - a. Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
 - 3. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 - 4. Solidly pack mineral-fiber insulation inside frames.
 - 5. Ceiling Struts: Extend struts vertically from top of frame at each jamb to supporting construction above unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction above. Provide adjustable wedged or bolted anchorage to frame jamb members.
 - 6. Installation Tolerances: Adjust sound control door frames for squareness, alignment, twist, and plumbness to the following tolerances:

- a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.
- C. Doors: Fit sound control doors accurately in frames, within clearances indicated below. Shim as necessary.
 - 1. Non-Fire-Rated Doors: Fit non-fire-rated doors accurately in frames with the following clearances:
 - a. Jambs: 1/8 inch (3 mm).
 - b. Head with Cam-Lift Hinges: As required by manufacturer, but not more than 3/8 inch (9.5 mm).
 - c. Sill: Manufacturer's standard.
 - d. Between Edges of Pairs of Doors: 1/8 inch (3 mm).
 - 2. Fire-Rated Doors: Install fire-rated doors with clearances according to NFPA 80.
- D. Sound Control Seals: Where seals have been factory prefit and preinstalled and subsequently removed for shipping, reinstall seals and adjust according to manufacturer's written instructions.
- E. Cam-Lift Hinges: Install hinges according to manufacturer's written instructions.
- F. Thresholds: Set thresholds in full bed of sealant complying with requirements in Section 07 92 00 "Joint Sealants."

3.04 ADJUSTING AND CLEANING

- A. Final Adjustments: Check and adjust seals, door bottoms, and other sound control hardware items right before final inspection. Leave work in complete and proper operating condition.
- B. Remove and replace defective work, including defective or damaged sound seals and doors and frames that are warped, bowed, or otherwise unacceptable.
 - 1. Adjust gaskets, gasket retainers, and retainer covers to provide contact required to achieve STC rating.

- C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible, rust-inhibitive, air-drying primer.
- D. Metallic-Coated Surfaces: Clean abraded areas of doors and repair with galvanizing repair paint according to manufacturer's written instructions.

END OF SECTION

SECTION 08 41 13

ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Aluminum-framed storefront systems.
2. Aluminum-framed entrance door systems. (ALUM-2)

1.02 PREINSTALLATION MEETINGS

- ###### A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For aluminum-framed entrances and storefronts. Include plans, elevations, sections, full-size details, and attachments to other work.

1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
2. Include full-size isometric details of each type of vertical-to-horizontal intersection of aluminum-framed entrances and storefronts, showing the following:
 - a. Joinery, including concealed welds.
 - b. Anchorage.
 - c. Expansion provisions.
 - d. Glazing.
 - e. Flashing and drainage.
3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.
4. Include point-to-point wiring diagrams showing the following:

- a. Power requirements for each electrically operated door hardware.
 - b. Location and types of switches, signal device, conduit sizes, and number and size of wires.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.
- E. Entrance Door Hardware Schedule: Prepared by or under supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams. Coordinate final entrance door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of entrance door hardware.

1.04 INFORMATIONAL SUBMITTALS

- A. Certificates:
 - 1. Energy Performance Certificates: For aluminum-framed entrances and storefronts, accessories, and components, from manufacturer.
 - a. Basis for Certification: NFRC-certified energy performance values for each aluminum-framed entrance and storefront.
- B. Test and Evaluation Reports:
 - 1. Product Test Reports: For aluminum-framed entrances and storefronts, for tests performed by qualified testing agency.
- C. Source Quality-Control Submittals:
 - 1. Source quality-control reports.
- D. Field Quality-Control Submittals:
 - 1. Field quality-control reports.
- E. Quality-Control Program: Developed specifically for Project, including fabrication and installation, in accordance with recommendations in ASTM C1401. Include periodic quality-control reports.
- F. Qualification Statements:
 - 1. For Installer and field testing agency.
- G. Sample warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For aluminum-framed entrances and storefronts.
- B. Maintenance Data for Structural Sealant: For structural-sealant-glazed storefront. Include ASTM C1401 recommendations for post-installation-phase quality-control program.

1.06 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Installers: An entity that employs installers and supervisors who are trained and approved by manufacturer and that employs a qualified glazing contractor for this Project who is certified under the North American Contractor Certification Program (NACC) for Architectural Glass & Metal (AG&M) contractors.
 - 2. Testing Agency: Qualified in accordance with ASTM E699 for testing indicated and acceptable to Owner and Engineer.
- B. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.
 - 1. Do not change intended aesthetic effects, as judged solely by Engineer, except with Engineer's approval. If changes are proposed, submit comprehensive explanatory data to Engineer for review.
- C. Structural-Sealant Glazing: Comply with ASTM C1401 for design and installation of storefront systems that include structural glazing.
- D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - 1. Build mockup as shown on Drawings, including supports, attachments, and accessories. Refer to Section 01 43 39 "Mockups."
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.

1.07 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Submit to structural glazing sealant manufacturer, for testing indicated below, Samples of each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member that is in close proximity to or is touching the structural or nonstructural sealants of a structural glazed system.

1. Compatibility: Test materials or components using ASTM C1087.
2. Adhesion: Test for adhesion or lack of adhesion of a structural sealant to the surface of another material or component using ASTM C1135.
3. Submit no fewer than eight pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
4. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
5. For materials failing tests, obtain sealant manufacturer's written instructions for corrective measures, including the use of specially formulated primers.
6. Testing will not be required if data based on previous testing of current sealant products match those submitted.

1.08 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed entrances and storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Structural failures, including, but not limited to, excessive deflection.
 - b. Noise or vibration created by wind and thermal and structural movements.
 - c. Deterioration of metals and other materials beyond normal weathering.
 - d. Water penetration through fixed glazing and framing areas.
 - e. Failure of operating components.
2. Warranty Period: 10 years from date of Substantial Completion.

- B. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.

- c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
- 2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain all components of aluminum-framed entrance and storefront system, including framing and accessories, from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed entrances and storefronts representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

- 1. Aluminum-framed entrances and storefronts shall withstand movements of supporting structure, including, but not limited to, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
 - 2. Failure also includes the following:
 - a. Thermal stresses transferring to building structure.
 - b. Glass breakage.
 - c. Noise or vibration created by wind and thermal and structural movements.
 - d. Loosening or weakening of fasteners, attachments, and other components.
 - e. Failure of operating units.

- B. Structural Loads:

- 1. Wind Loads: As indicated on Drawings.

- C. Deflection of Framing Members Supporting Glass: At design wind load, as follows:

- 1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans of up to 13 feet 6 inches (4.1 m) and to 1/240 of clear span plus 1/4 inch (6.35 mm) for spans greater than 13 feet 6 inches (4.1 m).
 - 2. Deflection Parallel to Glazing Plane: Limited to amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and that which reduces edge clearance between framing members and glazing or other fixed components to less than 1/8 inch (3.2 mm).

- a. Operable Units: Provide a minimum 1/16-inch (1.6-mm) clearance between framing members and operable units.
- 3. Cantilever Deflection: Limited to $2L/175$ at unsupported cantilevers.
- D. Structural: Test in accordance with ASTM E330/E330M as follows:
 - 1. When tested at positive and negative wind-load design pressures, storefront assemblies, including entrance doors, do not evidence deflection exceeding specified limits.
 - 2. When tested at 150 percent of positive and negative wind-load design pressures, storefront assemblies, including entrance doors and anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
 - 3. Test Durations: As required by design wind velocity, but not less than 10 seconds.
- E. Water Penetration under Static Pressure: Test in accordance with ASTM E331 as follows:
 - 1. No evidence of water penetration through fixed glazing and framing areas, including entrance doors, when tested in accordance with a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 10 lbf/sq. ft. (480 Pa).
- F. Seismic Performance: Aluminum-framed entrances and storefronts shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
- G. Energy Performance: Certified and labeled by manufacturer for energy performance as follows:
 - 1. Thermal Transmittance (U-factor):
 - a. Fixed Glazing and Framing Areas: U-factor for the system of not more than 0.43 Btu/sq. ft. x h x deg F as determined in accordance with NFRC 100.
 - b. Entrance Doors: U-factor of not more than 0.45 Btu/sq. ft. x h x deg F as determined in accordance with NFRC 100.
 - 2. Solar Heat-Gain Coefficient (SHGC):
 - a. Fixed Glazing and Framing Areas: SHGC for the system of not more than 0.47 as determined in accordance with NFRC 200.
 - b. Entrance Doors: SHGC of not more than 0.47 as determined in accordance with NFRC 200.
 - 3. Air Leakage:

- a. Fixed Glazing and Framing Areas: Air leakage for the system of not more than 0.06 cfm/sq. ft. (0.30 L/s per sq. m) at a static-air-pressure differential of 6.24 lbf/sq. ft. (300 Pa) when tested in accordance with ASTM E283.
 - b. Entrance Doors: Air leakage of not more than 1.0 cfm/sq. ft. (5.08 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).
 - 4. Condensation Resistance Factor (CRF):
 - a. Fixed Glazing and Framing Areas: CRF for the system of not less than 70 as determined in accordance with AAMA 1503.
 - b. Entrance Doors: CRF of not less than 70 as determined in accordance with AAMA 1503.
 - H. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 - I. Structural-Sealant Joints:
 - 1. Designed to carry gravity loads of glazing.
 - J. Structural Sealant: ASTM C1184. Capable of withstanding tensile and shear stresses imposed by structural-sealant-glazed, aluminum-framed entrances and storefronts without failing adhesively or cohesively. When tested for preconstruction adhesion and compatibility, cohesive failure of sealant shall occur before adhesive failure.
 - 1. Adhesive failure occurs when sealant pulls away from substrate cleanly, leaving no sealant material behind.
 - 2. Cohesive failure occurs when sealant breaks or tears within itself but does not separate from each substrate, because sealant-to-substrate bond strength exceeds sealant's internal strength.
- 2.03 STOREFRONT SYSTEMS
- A. Basis-of-Design Product: Subject to compliance with requirements, provide OldCastle BuildingEnvelope (OBE); Series 6000 Thermal MultiPlane or a comparable product by one of the following:
 - 1. Arcadia, Inc.
 - 2. EFCO Corporation.
 - 3. Kawneer Company, Inc.; Arconic Corporation.

4. YKK AP America Inc.

B. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.

1. Exterior Framing Construction: Thermally broken.

2. Glazing System: Retained mechanically with gaskets on two sides and structural sealant on two sides.

3. Glazing Plane: Front.

4. Finish: High-performance organic finish.

5. Fabrication Method: Field-fabricated stick system.

6. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

7. Steel Reinforcement: As required by manufacturer.

C. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

D. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

2.04 ENTRANCE DOOR SYSTEMS

A. Basis-of-Design Product: Subject to compliance with requirements, provide OldCastle BuildingEnvelope (OBE); Thermal Composite Entrances. or a comparable product by one of the following:

1. Arcadia, Inc.

2. EFCO Corporation.

3. Kawneer Company, Inc.; Arconic Corporation.

4. YKK AP America Inc.

B. Entrance Doors: Manufacturer's standard glazed entrance doors for manual-swing or automatic operation.

1. Door Construction: 2- to 2-1/4-inch (50.8- to 57.2-mm) overall thickness, with minimum 0.125-inch- (3.2-mm-) thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods.

- a. Thermal Construction: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.
- 2. Door Design: Medium stile; 3-1/2-inch (88.9-mm) nominal width.
- 3. Glazing Stops and Gaskets: Beveled, snap-on, extruded-aluminum stops and preformed gaskets.
 - a. Provide nonremovable glazing stops on outside of door.
- 4. Finish: Match adjacent storefront framing finish.

2.05 ENTRANCE DOOR HARDWARE

- A. Entrance Door Hardware: Hardware not specified in this Section is specified in Section 08 71 00 "Door Hardware."
- B. General: Provide entrance door hardware and entrance door hardware sets indicated in door and frame schedule for each entrance door, to comply with requirements in this Section.
 - 1. Entrance Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and products complying with BHMA standard referenced.
 - 2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
 - 3. Opening-Force Requirements:
 - a. Egress Doors: Not more than 15 lbf (67 N) to release the latch and not more than 30 lbf (133 N) to set the door in motion and not more than 15 lbf (67 N) to open the door to its minimum required width.
- C. Designations: Requirements for design, grade, function, finish, quantity, size, and other distinctive qualities of each type of entrance door hardware are indicated in "Entrance Door Hardware Sets" Article. Products are identified by using entrance door hardware designations as follows:
 - 1. Named Manufacturers' Products: Manufacturer and product designation are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in "Entrance Door Hardware Sets" Article.
 - 2. References to BHMA Standards: Provide products complying with these standards and requirements for description, quality, and function.
- D. Pivot Hinges: BHMA A156.4, Grade 1.

1. Offset-Pivot Hinges: Provide top, bottom, and intermediate offset pivots at each door leaf.

E. Butt Hinges: BHMA A156.1, Grade 1, radius corner.

1. Nonremovable Pins: Provide setscrew in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while entrance door is closed.
2. Exterior Hinges: Stainless steel, with stainless steel pin.
3. Quantities:
 - a. For doors up to 87 inches (2210 mm) high, provide three hinges per leaf.

F. Mortise Auxiliary Locks: BHMA A156.5, Grade 1.

G. Panic Exit Devices: BHMA A156.3, Grade 1, listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing in accordance with UL 305.

H. Cylinders:

1. As specified in Section 08 71 00 "Door Hardware."

I. Weather Stripping: Manufacturer's standard replaceable components.

1. Compression Type: Made of ASTM D2000 molded neoprene or ASTM D2287 molded PVC.
2. Sliding Type: AAMA 701/702, made of wool, polypropylene, or nylon woven pile with nylon-fabric or aluminum-strip backing.

J. Weather Sweeps: Manufacturer's standard exterior-door bottom sweep with concealed fasteners on mounting strip.

K. Finger Guards: Manufacturer's standard collapsible neoprene or PVC gasket anchored to frame hinge-jamb at center-pivoted doors.

2.06 GLAZING

A. Glazing: Comply with Section 08 80 00 "Glazing."

B. Glazing Sealants: Comply with Section 08 80 00 "Glazing."

C. Structural Glazing Sealants: ASTM C1184 chemically curing silicone formulation that is compatible with system components with which it comes in contact; specifically formulated and tested for use as structural sealant and approved by structural-sealant manufacturer for use in storefront system indicated.

1. Color: As selected by Engineer from manufacturer's full range of colors.
- D. Weatherseal Sealants: ASTM C920 for Type S; Grade NS; Class 25; Uses NT, G, A, and O; chemically curing silicone formulation that is compatible with structural sealant and other system components with which it comes in contact; recommended by structural-sealant, weatherseal-sealant, and structural-sealant-glazed storefront manufacturers for this use.

1. Color: Match structural sealant.

2.07 MATERIALS

- A. Sheet and Plate: ASTM B209 (ASTM B209M).
- B. Extruded Bars, Rods, Profiles, and Tubes: ASTM B221 (ASTM B221M).
- C. Structural Profiles: ASTM B308/B308M.
- D. Steel Reinforcement:
1. Structural Shapes, Plates, and Bars: ASTM A36/A36M.
 2. Cold-Rolled Sheet and Strip: ASTM A1008/A1008M.
 3. Hot-Rolled Sheet and Strip: ASTM A1011/A1011M.
- E. Steel Reinforcement Primer: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods in accordance with recommendations in SSPC-SP COM, and prepare surfaces in accordance with applicable SSPC standard.

2.08 ACCESSORIES

- A. Automatic Door Operators: Section 08 71 13 "Power Door Operators."
- B. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
 2. Reinforce members as required to receive fastener threads.
 3. Use exposed fasteners with countersunk Phillips screw heads, finished to match framing system.

- C. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch (25.4 mm) that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.
 - 1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A123/A123M or ASTM A153/A153M requirements.
- D. Concealed Flashing: Dead-soft, 0.018-inch- (0.457-mm-) thick stainless steel, complying with ASTM A240/A240M, of type recommended by manufacturer.
- E. Bituminous Paint: Cold-applied asphalt-mastic paint containing no asbestos, formulated for 30-mil (0.762-mm) thickness per coat.
- F. Rigid PVC filler.

2.09 FABRICATION

- A. Form or extrude aluminum shapes before finishing.
- B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- C. Fabricate components that, when assembled, have the following characteristics:
 - 1. Profiles that are sharp, straight, and free of defects or deformations.
 - 2. Accurately fitted joints with ends coped or mitered.
 - 3. Physical and thermal isolation of glazing from framing members.
 - 4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
 - 5. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
- D. Mechanically Glazed Framing Members: Fabricate for flush glazing without projecting stops.
- E. Structural-Sealant-Glazed Framing Members: Include accommodations for using temporary support device to retain glazing in place while structural sealant cures.
- F. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.
 - 1. At interior and exterior doors, provide compression weather stripping at fixed stops.

- G. Entrance Doors: Reinforce doors as required for installing entrance door hardware.
 - 1. At exterior doors, provide weather sweeps applied to door bottoms.
- H. Entrance Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.
- I. After fabrication, clearly mark components to identify their locations in Project in accordance with Shop Drawings.

2.10 ALUMINUM FINISHES

- A. High-Performance Organic Finish, Two-Coat PVDF: Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in color coat.
 - 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 2. Color and Gloss: Medium Gray.

2.11 SOURCE QUALITY CONTROL

- A. Structural Sealant: Perform quality-control procedures complying with ASTM C1401 recommendations, including, but not limited to, assembly material qualification procedures, sealant testing, and assembly fabrication reviews and checks.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Comply with manufacturer's written instructions.
- B. Do not install damaged components.
- C. Fit joints to produce hairline joints free of burrs and distortion.
- D. Rigidly secure nonmovement joints.

- E. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
- F. Seal perimeter and other joints watertight unless otherwise indicated.
- G. Metal Protection:
 - 1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.
 - 2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.
- H. Set continuous sill members and flashing in full sealant bed, as specified in Section 07 92 00 "Joint Sealants," to produce weathertight installation.
- I. Install joint filler behind sealant as recommended by sealant manufacturer.
- J. Install components plumb and true in alignment with established lines and grades.

3.03 INSTALLATION OF GLAZING

- A. Install glazing as specified in Section 08 80 00 "Glazing."

3.04 INSTALLATION OF STRUCTURAL GLAZING

- A. Prepare surfaces that will contact structural sealant in accordance with sealant manufacturer's written instructions, to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.
- B. Set glazing into framing in accordance with sealant manufacturer and framing manufacturer's written instructions and standard practice. Use a spacer or backer as recommended by manufacturer.
- C. Set glazing with proper orientation so that coatings face exterior or interior as specified.
- D. Hold glazing in place using temporary retainers of type and spacing recommended by manufacturer, until structural sealant joint has cured.
- E. Apply structural sealant to completely fill cavity, in accordance with sealant manufacturer and framing manufacturer's written instructions and in compliance with local codes.
- F. Apply structural sealant at temperatures indicated by sealant manufacturer for type of sealant.
- G. Allow structural sealant to cure in accordance with manufacturer's written instructions.
- H. Clean and protect glass as indicated in Section 08 80 00 "Glazing."

3.05 INSTALLATION OF WEATHERSEAL SEALANT

- A. After structural sealant has completely cured, remove temporary retainers and insert backer rod between lites of glass as recommended by sealant manufacturer.
- B. Install weatherseal sealant to completely fill cavity, in accordance with sealant manufacturer's written instructions, to produce weatherproof joints.

3.06 INSTALLATION OF ALUMINUM-FRAMED ENTRANCE DOORS

- A. Install entrance doors to produce smooth operation and tight fit at contact points.
 - 1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.
 - 2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware in accordance with entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

3.07 ERECTION TOLERANCES

- A. Install aluminum-framed entrances and storefronts to comply with the following maximum tolerances:
 - 1. Plumb: 1/8 inch in 10 feet (3.2 mm in 3 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
 - 2. Level: 1/8 inch in 20 feet (3.2 mm in 6 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
 - 3. Alignment:
 - a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch (12.7 mm) wide, limit offset from true alignment to 1/16 inch (1.6 mm).
 - b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch (12.7 to 25.4 mm) wide, limit offset from true alignment to 1/8 inch (3.2 mm).
 - c. Where surfaces are separated by reveal or protruding element of 1 inch (25.4 mm) wide or more, limit offset from true alignment to 1/4 inch (6 mm).
 - 4. Location: Limit variation from plane to 1/8 inch in 12 feet (3.2 mm in 3.6 m); 1/2 inch (12.7 mm) over total length.

3.08 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- B. Tests and Inspections: Perform the following tests on representative areas of aluminum-framed entrances and storefronts.
1. Water-Spray Test: Before installation of interior finishes has begun, areas designated by Engineer shall be tested in accordance with AAMA 501.2 and shall not evidence water penetration.
 - a. Perform a minimum of two tests in areas as directed by Engineer.
 - b. Perform tests in each test area as directed by Engineer. Perform at least three tests, prior to 10, 35, and 70 percent completion.
 2. Air Leakage: ASTM E783 at 1.5 times the rate specified for laboratory testing in "Performance Requirements" Article but not more than 0.09 cfm/sq. ft. (0.45 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).
 - a. Perform a minimum of two tests in areas as directed by Engineer.
 - b. Perform tests in each test area as directed by Engineer. Perform at least three tests, prior to 10, 35, and 70 percent completion.
 3. Water Penetration: ASTM E1105 at a minimum uniform static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft. (300 Pa), and shall not evidence water penetration.
 4. Structural-Sealant Adhesion: Test structural sealant in accordance with recommendations in ASTM C1401, Destructive Test Method A, "Hand Pull Tab (Destructive)," Appendix X2.
 - a. Test a minimum of four areas on each building facade.
 - b. Repair installation areas damaged by testing.
 5. Egress Door Inspections: Inspect each aluminum-framed entrance door equipped with panic hardware, each aluminum-framed entrance door located in an exit enclosure, each electrically controlled aluminum-framed egress door, and each aluminum-framed entrance door equipped with special locking arrangements, in accordance with NFPA 101, Section 7.2.1.15.
- C. Aluminum-framed entrances and storefronts will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

SECTION 08 56 72

SOUND CONTROL WINDOWS

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide acoustically rated window assemblies in the High Service Pump Station.

1.02 PERFORMANCE REQUIREMENTS

- A. Sound Rating: Provide window assemblies identical to those of assemblies tested by an acoustical testing agency, and have the following minimum ratings:
 - 1. STC Rating: Conforming to tests performed in accordance with ASTM E90 and classified in accordance with ASTM E413-90.
 - 2. NIC Rating: The windows shall provide a Noise Isolation Class (NIC) which is no less than 5 points below the scheduled STC performance. Test shall be measured in accordance with ASTM E-336-97 and classified in accordance with ASTM E413-90.

1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Not less than five years documented successful experience in installation of work similar to Work of this Project.
- B. Acceptance Testing
 - 1. The installations shall be deemed acceptable if they meet or exceed the NIC-rating, as indicated herein, conforming to tests performed in accordance with ASTM E-336-97 and classified in accordance with ASTM E413-90.

1.04 SUBMITTALS

- A. Laboratory Test Results - At the time of bidding, submit to the Engineer the results of acoustical laboratory tests showing that a full installation of the entire window assembly which is proposed for installation has been measured in accordance with ASTM E90 and classified in accordance with ASTM E413-90 and has met or exceeded the STC (Sound Transmission Class) rating as scheduled.
- B. Field Tests Results - At the time of bidding, submit to the Engineer and the Acoustical Consultant the results of at least two field tests performed by an Independent Acoustical Consultant showing comparable installations that have been measured in accordance with ASTM E-336-97 and classified in accordance with ASTM E413-90.

- C. Shop Drawings - Submit drawings showing complete details including all dimensions, materials, finishes, mounting hardware and other pertinent information as may be requested.
- D. Samples: Submit sample of metal frame, in finish selected by Engineer from manufacturer's standards.

PART 2 - PRODUCTS

2.01 ACOUSTICALLY RATED WINDOW ASSEMBLY

- A. Basis-of-Design Product: Subject to compliance with the requirements, provide Overly Model No. 5592278 or comparable product from one of the following:
 - 1. Krieger Specialty Products Company.
 - 2. Industrial Acoustics Company.
 - 3. Noise Barriers, LLC.
- B. Window Assembly: Fabricate to achieve the scheduled STC rating of 55, with minimum requirements as shown on the Drawings and as described below:
 - 1. First lite: Laminated glass consisting of 1/4 inch thick optically clear glass ply, 0.030-inch interlayer, and 1/4 inch thick optically clear glass ply.
 - 2. Second lite: Laminated glass consisting of 1/4 inch optically clear glass ply, 0.030-inch interlayer, 1/4 inch optically clear glass ply, 0.030 inch interlayer. and 1/4 inch optically clear glass ply.
- C. Acoustically Rated Window Assemblies shall be complete, window and frame assemblies that will meet or exceed the scheduled performance and be fabricated as detailed on the Contract Drawings.
- D. Window assemblies shall be fixed, with metal frame, finish as selected by Engineer from manufacturer's standard finishes.
 - 1. Constructed from Galvannealed material conforming to ASTM A653 (A60) with a coating weight of not less than 0.60 ounces per square foot. Steel shapes shall comply with ASTM A36 and steel bars with ASTM A108, Grade 1018.
 - 2. Frames shall be 14-gauge minimum welded units with integral trim and shipped with temporary spreader. Knock-down frames are not acceptable unless sizes of frames exceed shipping limitations. After installation, field splices required because of shipping limitations must be field welded by certified welders per manufacturer's instructions and in accordance with AWS D1.1/D1.3.

3. Provide suitable anchors to properly install frames in partition types shown Drawings.
- E. The glazing shall be as necessary to achieve the specified transmission loss performance.
- F. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer, to comply with system performance requirements.
- G. Finish: Refer to Drawings for finish colors.
 1. Factory-Applied Paint Finish: Manufacturer's standard primer and finish coats, complying with SDI A250.3 for performance and acceptance criteria.
 2. Color and Gloss: Match finish color and gloss specified in Section 08 41 13 "Aluminum-Framed Entrances and Storefronts."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surrounding construction for compliance with requirements for installation. Notify Engineer of any discrepancies. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 ADJUSTMENT OF ASSEMBLY

- A. For factory fabricated window assemblies, adjustment of frame and acoustic gaskets shall take place at the factory to ensure proper fit, and performance. The entire unit (frame, glazing and gaskets) shall be shipped to the project site as one unit.
- B. For site-built assemblies an authorized representative of the window manufacturer shall personally supervise adjusting of acoustical seals until any and all acoustical leaks have been resolved. All costs associated with this supervision shall be borne by the window manufacturer.

3.03 INSTALLATION

- A. Prior to installation, secure the services of a qualified representative of the manufacturer to visit the job site and instruct the contractor's personnel in proper installation and adjustment of the assemblies or secure services of manufacturer's factory trained and authorized installer to perform installation of assemblies.
- B. Install work of this Section in strict accordance with approved shop drawings and manufacturer's recommended installation instructions. Where installations require field welding, all work must be performed by certified welders in accordance with AWS D1.1/D1.3.

- C. Upon installation, secure the services of a qualified representative of the manufacturer to visit the jobsite and inspect the complete installation of the fixed window assemblies, and direct installer in correcting any non-conforming items found.
- D. Install assemblies plumb, straight, square, level and in their proper elevation, plane and location. All work shall be complete in every detail, and the finished work shall be clean and adjusted for the Engineer prior to final acceptance.

3.04 DEMONSTRATION

- A. Demonstrate the maintenance of the windows to the Owner's designated representative.

END OF SECTION

SECTION 08 71 00
DOOR HARDWARE

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes door hardware.
- B. Related Requirements:
 - 1. Section 08 11 19 "Stainless-Steel Doors and Frames" for door silencers provided as part of stainless steel frames.
 - 2. Section 08 11 16 "Aluminum Doors and Frames" for door silencers provided as part of aluminum frames.
 - 3. Section 08 14 16 "Flush Wood Doors."
 - 4. Section 08 33 23 "Overhead Coiling Doors" for door hardware provided as part of overhead coiling door assemblies.
 - 5. Section 08 34 73.13 "Metal Sound Control Door Assemblies" for hinges and gasketing provided as part of sound-rated door assemblies.
 - 6. Section 08 41 13 "Aluminum-Framed Entrances and Storefronts" for entrance door hardware.
 - 7. Section 08 91 19 "Fixed Louvers" for hardware associated with exterior louver screen walls.
 - 8. Division 28 sections for coordination of access control system components.

1.02 SUBMITTALS, GENERAL

- A. General: Submit all action submittals (except Samples for Verification) and informational submittals required by this Section concurrently.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction and installation details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 1. Hinges.
 - 2. Continuous hinges.

3. Cylindrical locks.
4. Exit devices and auxiliary items.
5. Lock cylinders.
6. Construction cores.
7. Keying system/keys.
8. Surface closers.
9. Wall stops.
10. Door gasketing.
11. Metal protective trim units.
12. Auxiliary hardware.

B. Shop Drawings: Details of electrified door hardware, indicating the following:

1. Wiring Diagrams: For power, signal, and control wiring and including the following:
 - a. Details of interface of electrified door hardware and building safety and security systems.
2. Operation Narrative: Describe the operation of doors controlled by electrified door hardware.

C. Samples for Verification: For exposed door hardware of each type required, in each finish specified, prepared on Samples of size indicated below. Tag Samples with full description for coordination with the door hardware schedule.

1. Sample Size: Full-size units or minimum 2-by-4-inch Samples for sheet and 4-inch long Samples for other products.

D. Door Hardware Schedule: Prepared by or under the supervision of Installer, detailing fabrication and assembly of door hardware, as well as installation procedures and diagrams. Coordinate final door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.

1. Format: Use same scheduling sequence and format and use same door numbers as in the Contract Documents.
2. Content: Include the following information:

- a. Identification number, location, hand, fire rating, size, and material of each door and frame.
 - b. Locations of each door hardware set, cross-referenced to Drawings on floor plans and to door and frame schedule.
 - c. Complete designations, including name and manufacturer, type, style, function, size, quantity, function, and finish of each door hardware product.
 - d. Description of electrified door hardware sequences of operation and interfaces with other building control systems.
 - e. Fastenings and other pertinent information.
 - f. Explanation of abbreviations, symbols, and codes contained in schedule.
 - g. Mounting locations for door hardware.
- E. Keying Schedule: Prepared by or under the supervision of Installer, detailing Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations that are coordinated with the Contract Documents.
- F. Warranty: Sample of special warranty specified in this Section.
- 1.04 INFORMATIONAL SUBMITTALS
 - A. Product Certificates: For electrified door hardware, from the manufacturer.
 - 1. Certify that door hardware approved for use on types and sizes of labeled fire-rated doors complies with listed fire-rated door assemblies.
- 1.05 CLOSEOUT SUBMITTALS
 - A. Maintenance Data: For each type of door hardware to include in maintenance manuals. Include final hardware and keying schedule.
 - B. Warranty: Executed special warranty specified in this Section.
- 1.06 QUALITY ASSURANCE
 - A. Installer Qualifications: Supplier of products and an employer of workers trained and approved by product manufacturers and an Architectural Hardware Consultant who is available during the course of the Work to consult with Contractor, Engineer, and Owner about door hardware and keying.
 - 1. Scheduling Responsibility: Preparation of door hardware and keying schedules.
 - 2. Engineering Responsibility: Preparation of data for electrified door hardware, including Shop Drawings, based on testing and engineering analysis of

manufacturer's standard units in assemblies similar to those indicated for this Project.

- B. Architectural Hardware Consultant Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and who is currently or has been certified by DHI as an AHC.
- C. Source Limitations: Obtain each type of door hardware from a single manufacturer.
- D. Fire-Rated Door Assemblies: Where fire-rated door assemblies are indicated, provide door hardware rated for use in assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C, unless otherwise indicated.
- E. Smoke, Draft-Control & STC Door Assemblies: Where assemblies are required, provide door hardware that meet requirements of assemblies tested according to UL 1784 and installed in compliance with NFPA 105 and other STC door testing data.
 - 1. Air Leakage Rate: Maximum air leakage of 0.3 cfm/sq. ft. at the tested pressure differential of 0.3-inch wg of water.
- F. Electrified Door Hardware: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- G. Means of Egress Doors: Latches do not require more than 15 lbf to release the latch. Locks do not require use of a key, tool, or special knowledge for operation.
- H. Accessibility Requirements: For door hardware on doors in an accessible route, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines, ICC/ANSI A117.1 and building code in effect for Project.
- I. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf.
 - 1. Comply with the following maximum opening-force requirements:
 - a. Interior, Non-Fire-Rated Hinged Doors: 5 lbf applied perpendicular to door.
 - b. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.
 - 2. Bevel raised thresholds with a slope of not more than 1:2. Provide thresholds not more than 1/2 inch high.
 - 3. Adjust door closer sweep periods so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.

- J. Preinstallation Conference: Conduct conference at Project site.
 - 1. Inspect and discuss preparatory work performed by other trades.
 - 2. Inspect and discuss electrical roughing-in for electrified door hardware.
 - 3. Review sequence of operation for each type of electrified door hardware.
- 1.07 DELIVERY, STORAGE, AND HANDLING
 - A. Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.
 - B. Tag each item or package separately with identification coordinated with the final door hardware schedule, and include installation instructions, templates, and necessary fasteners with each item or package.
- 1.08 COORDINATION
 - A. Installation Templates: Distribute for doors, frames, and other work specified to be factory prepared. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.
 - B. Electrical System Roughing-In: Coordinate layout and installation of electrified door hardware with connections to power supplies and building safety and security systems.
- 1.09 WARRANTY
 - A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including excessive deflection, cracking, or breakage.
 - b. Faulty operation of doors and door hardware.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 - 2. Warranty Period: Three years from date of Substantial Completion, unless otherwise indicated.
 - a. Exit Devices: 2 years
 - b. Manual Closers: 15 years
 - c. Locksets: 2 years

- d. Hinges: Lifetime

1.10 MAINTENANCE SERVICE

- A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

PART 2 - PRODUCTS

2.01 SCHEDULED DOOR HARDWARE

- A. Provide door hardware for each door as scheduled in Part 3 "Door Hardware Schedule" Article to comply with requirements in this Section.
 - 1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and named manufacturers' products or products equivalent in function and comparable in quality to named products.
 - 2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
 - 3. Electric Locking Hardware: Exit hardware shall always remain fully operational manually regardless of the status of electric latch.
- B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of door hardware are indicated in Part 3 "Door Hardware Schedule" Article. Products are identified by using door hardware designations, as follows:
 - 1. Named Manufacturers' Products: Manufacturer and product designation are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in Part 3 "Door Hardware Schedule" Article.
 - 2. References to BHMA Designations: Provide products complying with these designations and requirements for description, quality, and function.

2.02 HINGES

- A. Hinges: BHMA A156.1. Provide template-produced hinges for hinges installed on hollow-metal doors and hollow-metal frames.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Best

- b. Hager
- c. Stanley

2.03 CONTINUOUS HINGES

- A. Continuous Hinges: BHMA A156.26; minimum 0.120-inch-thick, hinge leaves with minimum overall width of 4 inches; fabricated to full height of door and frame and to template screw locations; with components finished after milling and drilling are complete.
- B. Continuous, Gear-Type Hinges: Extruded-aluminum, pinless, geared hinge leaves joined by a continuous extruded-aluminum channel cap; with concealed, self-lubricating thrust bearings.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABH
 - b. Best
 - c. Select

2.04 MECHANICAL LOCKS AND LATCHES

- A. Locks: Provide Provo product standard Corbin CL3300 series lockset with lever trim and functions as indicated in door hardware schedule.
- B. Lock Backset: 2-3/4 inches except where STC gasketing requires 3-3/4"
- C. Levers shall be capable of receiving Medeco X4 small format interchangeable core and construction core.
- D. Strikes: Provide manufacturer's standard strike for each lock bolt or latchbolt complying with requirements indicated for applicable lock or latch and with strike box and curved lip extended to protect frame; finished to match lock or latch.

2.05 EXIT DEVICES AND AUXILIARY ITEMS

- A. Exit Devices and Auxiliary Items: BHMA A156.3.
 - 1. Exits: Provide Provo product standard Corbin 5000 series exit devices. Where lever trim is specified, lever to match lockset design. Provide all necessary options and features to meet intended function.

2.06 LOCK CYLINDERS

- A. Lock Cylinders: Provide Provo product standard Medeco X4 SFIC system.
- B. Construction Cores: Provide construction cores that are replaceable by permanent cores. Provide 10 construction master keys.

2.07 KEYING

- A. Keying System: Factory registered, complying with guidelines in BHMA A156.28, Appendix A. Incorporate decisions made in keying conference.
 - 1. Master Key System: Change keys and a master key operate cylinders.
 - 2. Grand Master Key System: Change keys, a master key, and a grand master key operate cylinders.
- B. Keys: Nickel silver.
 - 1. Stamping: Permanently inscribe each key with a visual key control number and include the following notation:
 - a. Notation: "DO NOT DUPLICATE."
 - 2. Quantity: In addition to one extra key blank for each lock, provide the following:
 - a. Cylinder Change Keys: Three.
 - b. Master Keys: Five.
 - c. Grand Master Keys: Five.

2.08 ELECTRIC STRIKES

- A. Provide dual acting release strikes similar to Adams Rite 7440 series. Coordinate electric strikes with frame profiles and STC gasketing requirements.

2.09 SURFACE CLOSERS

- A. Surface Closers: BHMA A156.4; Cast iron with 1-1/2" minimum bore piston, rack-and-pinion hydraulic type with adjustable sweep and latch speeds controlled by key-operated valves and forged-steel main arm. Comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Best.
- b. LCN.

2.10 MECHANICAL STOPS AND HOLDERS

A. Wall Stops: BHMA A156.16; brushed chrome plated.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABH
 - b. Rockwood
 - c. Trimco

2.11 DOOR GASKETING

A. Door Gasketing: BHMA A156.22; air leakage not to exceed 0.50 cfm per foot of crack length for gasketing other than for smoke control, as tested according to ASTM E 283; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. National Guard Products.
 - b. Pemko.
 - c. Reese.
 - d. Zero.

2.12 METAL PROTECTIVE TRIM UNITS

A. Metal Protective Trim Units: BHMA A156.6; fabricated from 0.050-inch-thick stainless steel with manufacturer's standard machine or self-tapping screw fasteners.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABH
 - b. Rockwood

- c. Trimco.

2.13 AUXILIARY DOOR HARDWARE

A. Auxiliary Hardware: BHMA A156.16.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABH
 - b. Best
 - c. Trimco

2.14 FABRICATION

A. Manufacturer's Nameplate: Do not provide products that have manufacturer's name or trade name displayed in a visible location except in conjunction with required fire-rated labels and as otherwise approved by Engineer.

1. Manufacturer's identification is permitted on rim of lock cylinders only.

B. Base Metals: Produce door hardware units of base metal indicated, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18.

C. Fasteners: Provide door hardware manufactured to comply with published templates prepared for machine, wood, and sheet metal screws. Provide screws that comply with commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.

1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.

2. Fire-Rated Applications:

- a. Wood or Machine Screws: For the following:
 - (1) Hinges mortised to doors or frames; use threaded-to-the-head wood screws for wood doors.
 - (2) Strike plates to frames.

- (3) Closers to doors and frames.
- b. Steel Through Bolts: For the following unless door blocking is provided:
 - (1) Surface hinges to doors.
 - (2) Closers to doors and frames.
 - (3) Surface-mounted exit devices.
- 3. Spacers or Sex Bolts: For through bolting of hollow-metal doors.
- 4. Fasteners for Wood Doors: Comply with requirements in DHI WDHS.2, "Recommended Fasteners for Wood Doors."
- 5. Gasketing Fasteners: Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.

2.15 FINISHES

- A. Provide finishes complying with BHMA A156.18 as indicated in door hardware schedule.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire-rated door assembly construction, wall and floor construction, and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical power systems to verify actual locations of wiring connections before electrified door hardware installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

3.02 PREPARATION

- A. Steel Doors and Frames: For surface-applied door hardware, drill and tap doors and frames in accordance with ANSI/SDI A250.6.
- B. Wood Doors: Comply with DHI WDHS.5 "Recommended Hardware Reinforcement Locations for Mineral Core Wood Flush Doors."

3.03 INSTALLATION

- A. Mounting Heights: Mount door hardware units at heights to comply with the following unless otherwise indicated or required to comply with governing regulations.
 - 1. Custom Steel Doors and Frames: HMMA 831.
 - 2. Wood Doors: DHI's "Recommended Locations for Architectural Hardware for Wood Flush Doors."
- B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 09 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
 - 1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
 - 2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
- C. Hinges: Install types and in quantities indicated in door hardware schedule but not fewer than the number recommended by manufacturer for application indicated or one hinge for every 30 inches of door height, whichever is more stringent.
- D. Lock Cylinders: Install construction cores to secure building and areas during construction period.
 - 1. Replace construction cores with permanent cores as indicated in keying schedule.
- E. Key Control: Tag keys as determined by final keying schedule.
- F. Stops: Provide wall stops for doors unless other type stops are indicated in door hardware schedule.
- G. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.
- H. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.

- I. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

3.04 ADJUSTING

- A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
 - 1. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.
 - 2. Electric Strikes: Adjust horizontal and vertical alignment of keeper to properly engage lock bolt.
- B. Occupancy Adjustment: Approximately six months after date of Substantial Completion, Installer's Architectural Hardware Consultant is to examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors, door hardware, and electrified door hardware.

3.05 3.5 CLEANING AND PROTECTION

- A. Clean adjacent surfaces soiled by door hardware installation.
- B. Clean operating items as necessary to restore proper function and finish.
- C. Provide final protection and maintain conditions that ensure that door hardware is without damage or deterioration at time of Substantial Completion.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain door hardware and door hardware finishes.

3.07 DOOR HARDWARE SCHEDULE

Set #1 - Overhead, Monitored

Doors: 125A, 126A, EXT.101C, EXT.120C, EXT.120D, EXT.127

1	Padlock	41B-722T M1	606	BE
1	Door Position Switch	2707		SE

NOTE: Provide Medeco X4 SFIC core keyed into Owner's system as required, typical at all lockable devices.

Set #2 - Exterior, Card Reader

Doors: EXT.004, EXT.101A, EXT.101B, EXT.102B, EXT.120A, EXT.120B, EXT.123A, EXT.123B, EXT.125, EXT.126

1	Continuous Hinge	662HD	628	BE
1	Exit Device	ED5200 NIGHT LATCH (03)	630	CR
1	Electric Strike	AS REQUIRED	630	HS
1	Flush Pull	1111C	630	TR
1	Closer	4040XP HCUSH DA	689	LC
1	Kick Plate	K0050 8"	630	TR
1	Door Position Switch	1078C		SE
1	Door Sweep	C627 A		NA
1	Weatherstrip	700 ES		NA
1	Threshold	896 SS		NA

Set #3 - Card Reader
Doors: 101

1	Continuous Hinge	662HD	628	BE
1	Door Position Switch	1078C		SE
1	Cylindrical Lockset	CL3357 NZD	626	CR
1	Electric Strike	AS REQUIRED	630	HS
1	Closer	4040XP CUSH DA	689	LC
1	Kick Plate	K0050 8"	630	TR
1	Gasketing	2525 C		NA
1	Auto Door Bottom	320 S		NA

NOTE: At all STC rated doors, furnish complete STC package as required to meet ratings and certifications. Typical.

Set #4 - Card Reader
Doors: EXT.102A, EXT.123

2	Continuous Hinge	662HD	628	BE
2	Semi-Auto Flushbolt	3820 X 3810	630	TR
2	Dust Proof Strike	3911	630	TR
2	Deadbolt	8T3-7K	626	BE
1	Door Position Switch	1078C		SE
2	Flush Pull	1111C	630	TR
2	Closer	4040XP HCUSH DA	689	LC
2	Kick Plate	K0050 8"	630	TR
2	Door Sweep	C627 A		NA
2	Weatherstrip	700 ES		NA
2	Astragal	158 SA		NA
1	Threshold	896 SS		NA

Set #5
Doors: 001A, 001B

1	Continuous Hinge	662HD	628	BE
1	Exit Device	ED5200 X LEVER (08)	630	CR
1	Closer	4040XP CUSH	689	LC
1	Kick Plate	K0050 8"	630	TR
1	Gasketing	2525 C		NA

Set #6 - Card Reader
Doors: EXT.117, EXT.124

1	Continuous Hinge	662HD	628	BE
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1	Semi-Auto Flushbolt	3820 X 3810	630	TR
1	Dust Proof Strike	3911	630	TR
1	Exit Device	ED5600 NIGHT LATCH (03)	630	CR
1	Flush Pull	1111C	630	TR
1	Closer	4040XP HCUSH	689	LC
1	Kick Plate	K0050 8" x 34"	630	TR
1	Door Position Switch	1078C		SE
1	Door Sweep	C627 A		NA
1	Weatherstrip	700 ES		NA
1	Astragal	158 SA		NA
1	Auto Door Bottom	320 S		NA
1	Threshold	896 SS	630	NA

Set #7

Doors: 110, 117

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	BE
1	Cylindrical Lockset	CL3355 NZD	626	CR
1	Closer	4040XP CUSH DA	AL	LC
1	Kick Plate	K0050 8"	630	TR
1	Gasketing	2525 C		NA
1	Auto Door Bottom	320 S		NA

Set #8 - Privacy

Doors: 115, 116

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	BE
1	Privacy Set	CL3320 NZD	626	CR
1	Closer	4040XP H	689	LC
1	Kick Plate	K0050 8"	630	TR
1	Mop Plate	KM050 4"	630	TR
1	Wall Bumper	1270CVSV	626	TR
1	Gasketing	2525 C		NA

Set #9

Doors: 118

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	BE
1	Cylindrical Lockset	CL3355 NZD	626	CR
1	Wall Bumper	1270CVSV	626	TR
3	Silencer	1229A	GREY	

Set #10

Doors: 119, 210

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	BE
1	Cylindrical Lockset	CL3357 NZD	626	CR
1	Closer	4040XP H x ST	689	LC
1	Overhead Stop	N 4020	630	AB
1	Kick Plate	K0050 8"	630	TR
1	Gasketing	2525 C		NA

Set #11

Doors: 111, 112

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	BE
1	Cylindrical Lockset	CL3357 NZD	626	CR
1	Closer	4040XP H	689	LC
1	Kick Plate	K0050 8"	630	TR

1	Wall Bumper	1270CVSV	626	TR
1	Gasketing	2525 C		NA

Set #12

Doors: 113

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	ST
1	Cylindrical Lockset	CL3361 NZD	626	CR
1	Wall Bumper	1270CVSV	626	TR
1	Coat Hook	AM801	630	AB
1	Gasketing	2525 C		NA
1	Auto Door Bottom	320 S		NA

Set #13 - Auto Operator, Entry Vestibule, Card Reader

Doors: 101 DUPLICATE

1	Continuous Hinge	662HD	628	ST
1	Exit Device	ED4200 X LEVER	630	CR
1	Electric Strike	AS REQUIRED	630	HS
1	Low Energy Operator	D-4990		BE
2	Actuators	AS REQUIRED		
1	Overhead Stop	N 4020	630	AB
1	Auto Door Bottom	220NA		NA

Set #14 - Card Reader, Auto Operator

Doors: EXT.101 (CW-001)

1	Continuous Hinge	662HD	628	BE
1	Exit Device	ED4200 x LEVER	630	CR
1	Electric Strike	AS REQUIRED	630	HS
1	Low Energy Operator	D-4990		BE
2	Actuator	AS REQUIRED X RELAY	630	BE
1	Overhead Stop	N 4020	630	AB
1	Door Position Switch	1078C		SE
1	Door Sweep	C627 A		NA
1	Threshold	896 SS		NA

Set #15

Doors: 124, 125, 126, 127

3	Butt Hinge	CB1900R 4.5" x 4.5"	652	BE
1	Exit Device	ED4200 x LEVER	630	CR
1	Closer	4040XP CUSH DA	AL	LC
1	Kick Plate	K0050 8"	630	TR
1	Gasketing	2525 C		NA
1	Auto Door Bottom	320 S		NA

END OF SECTION

SECTION 08 80 00

GLAZING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Glass products.
2. Insulating glass.
3. Glazing sealants.
4. Glazing tapes.
5. Miscellaneous glazing materials.

B. Related Requirements:

1. Section 08 41 13 "Aluminum-Framed Entrances and Storefronts" for glazing sealants used in structural-sealant-glazed storefronts.
2. Section 08 56 72 "Sound Control Windows" for glazing used in acoustically-rated window assemblies.

1.02 DEFINITIONS

- A. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.
- B. Glass Thicknesses: Indicated by thickness designations in millimeters in accordance with ASTM C1036.
- C. IBC: International Building Code.
- D. Interspace: Space between lites of an insulating-glass unit.

1.03 COORDINATION

- A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances to achieve proper safety margins for glazing retention under each design load case, load case combination, and service condition.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Glass Samples: For each type of the following products; 12 inches (300 mm) square.
 - 1. Insulating glass.
 - 2. Spandrel glass.
- C. Glazing Accessory Samples: For sealants and colored spacers, in 12-inch (300-mm) lengths.
- D. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, manufacturers of fabricated glass units, glass testing agency, and sealant testing agency.
- B. Product Certificates: For glass.
- C. Product Test Reports: For fabricated glass and glazing sealants, for tests performed by a qualified testing agency.
 - 1. For glazing sealants, provide test reports based on testing current sealant formulations within previous 36-month period.
- D. Preconstruction adhesion and compatibility test report.
- E. Sample Warranties: For special warranties.

1.06 QUALITY ASSURANCE

- A. Fabricated-Glass Manufacturer Qualifications: A qualified manufacturer of fabricated glass units who is approved and certified by primary glass manufacturer.
- B. Installer Qualifications: A qualified glazing contractor for this Project who is certified under the North American Contractor Certification Program (NACC) for Architectural Glass & Metal (AG&M) contractors.
- C. Glass Testing Agency Qualifications: A qualified independent testing agency accredited according to the NFRC CAP 1 Certification Agency Program.
- D. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1021 to conduct the testing indicated.
- E. Mockups: Install glazing in mockups of assemblies as shown on Drawings and as specified in Section 01 43 39 "Mockups." Use materials and installation methods specified in this Section.

1.07 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Test each glass product, tape sealant, gasket, glazing accessory, and glass-framing member for adhesion to and compatibility with elastomeric glazing sealants.
 - 1. Testing is not required if data are submitted based on previous testing of current sealant products and glazing materials matching those submitted.
 - 2. Use ASTM C1087 to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to glass, tape sealants, gaskets, and glazing channel substrates.
 - 3. Test no fewer than eight Samples of each type of material, including joint substrates, shims, sealant backings, secondary seals, and miscellaneous materials.
 - 4. Schedule enough time for testing and analyzing results to prevent delaying the Work.
 - 5. For materials failing tests, submit sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Protect glazing materials in accordance with manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.
- B. Comply with insulating-glass manufacturer's written instructions for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

1.09 FIELD CONDITIONS

- A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.
 - 1. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or are below 40 deg F (4.4 deg C).

1.10 WARRANTY

- A. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's

written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.

1. Warranty Period: 10 years from date of Substantial Completion.

- B. Manufacturer's Special Warranty for Insulating Glass: Manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is obstruction of vision by dust, moisture, or film on interior surfaces of glass.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations for Glass: Obtain glass from single source from single manufacturer.
- B. Source Limitations for Glazing Accessories: For each product and installation method, obtain from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.
- B. Structural Performance: Glazing shall withstand the following design loads within limits and under conditions indicated determined in accordance with the IBC and ASTM E1300:
1. Design Wind Pressures: As indicated on Drawings.
2. Maximum Lateral Deflection: For glass supported on all four edges, limit center-of-glass deflection at design wind pressure to not more than 1/50 times the short-side length or 1 inch (25 mm), whichever is less.
3. Thermal Loads: Design glazing to resist thermal stress breakage induced by differential temperature conditions and limited air circulation within individual glass lites and insulated glazing units.
- C. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

- D. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
1. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
 2. U-Factors: Center-of-glazing values, in accordance with NFRC 100 and based on most current non-beta version of LBL's WINDOW computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).
 3. SHGC and Visible Transmittance: Center-of-glazing values, in accordance with NFRC 200 and based on most current non-beta version of LBL's WINDOW computer program.
 4. Visible Reflectance: Center-of-glazing values, in accordance with NFRC 300.

2.03 GLASS PRODUCTS, GENERAL

- A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.
1. NGA Publications: "Glazing Manual."
 2. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."
- B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC or another certification agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
- C. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of the IGCC.
- D. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than thickness indicated.
1. Minimum Glass Thickness for Exterior Lites: 6 mm.
- E. Strength: Where heat-strengthened float glass is indicated, provide heat-strengthened float glass or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where fully tempered float glass is indicated, provide fully tempered float glass.

2.04 GLASS PRODUCTS

- A. Low-Iron Annealed Float Glass: ASTM C1036, Type I, Class I (clear), Quality-Q3.
- B. Fully Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.
 - 1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.
- C. Heat-Strengthened Float Glass: ASTM C1048, Kind HS (heat strengthened), Type I, Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.
 - 1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.

2.05 INSULATING GLASS

- A. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified in accordance with ASTM E2190.
 - 1. Sealing System: Dual seal, with manufacturer's standard primary and secondary sealants.
 - 2. Perimeter Spacer: Aluminum with powdered metal paint finish in color selected by Engineer.
 - 3. Desiccant: Molecular sieve or silica gel, or a blend of both.

2.06 GLAZING SEALANTS

- A. General:
 - 1. Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
 - 2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
 - 3. Colors of Exposed Glazing Sealants: As selected by Engineer from manufacturer's full range of industry colors.
- B. Neutral-Curing Silicone Glazing Sealant, Class 50: Complying with ASTM C920, Type S, Grade NS, Use NT.

2.07 GLAZING TAPES

- A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C1281 and AAMA 800 for products indicated below:
 - 1. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

2.08 MISCELLANEOUS GLAZING MATERIALS

- A. General: Provide products of material, size, and shape complying with referenced glazing standard, recommended in writing by manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.
- B. Cleaners, Primers, and Sealers: Types recommended by sealant manufacturer.
- C. Cylindrical Glazing Sealant Backing: ASTM C1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

2.09 FABRICATION OF GLAZING UNITS

- A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.
 - 1. Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:
 - 1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
 - 2. Presence and functioning of weep systems.

3. Minimum required face and edge clearances.
4. Effective sealing between joints of glass-framing members.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.
- B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that leave visible marks in the completed Work.

3.03 GLAZING, GENERAL

- A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.
- B. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.
- C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
- D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
- E. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.
- F. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).
 1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
 2. Provide 1/8-inch- (3-mm-) minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

- G. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and in accordance with requirements in referenced glazing publications.
- H. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.
- I. Set glass lites with proper orientation so that coatings face exterior or interior as specified.

3.04 TAPE GLAZING

- A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.
- B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.
- C. Cover vertical framing joints by applying tapes to heads and sills first, then to jambs. Cover horizontal framing joints by applying tapes to jambs, then to heads and sills.
- D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.
- E. Do not remove release paper from tape until right before each glazing unit is installed.
- F. Apply heel bead of elastomeric sealant.
- G. Center glass lites in openings on setting blocks, and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.
- H. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.05 SEALANT GLAZING (WET)

- A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.
- B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.
- C. Tool exposed surfaces of sealants to provide a substantial wash away from glass.

3.06 CLEANING AND PROTECTION

- A. Immediately after installation, remove nonpermanent labels and clean surfaces.

- B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.
 - 1. If, despite such protection, contaminating substances do contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.
- C. Remove and replace glass that is damaged during construction period.
- D. Wash glass on both exposed surfaces not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

3.07 INSULATING GLASS SCHEDULE

- A. Low-E-Coated, Ultra Clear Insulating Glass, Type GL-1:
 - 1. Basis-of-Design Product: Vitro Glazing, Solarban 72 Starphire+Starphire.
 - 2. Overall Unit Thickness: 1 inch (25 mm).
 - 3. Minimum Thickness of Each Glass Lite: 6 mm.
 - 4. Outdoor Lite: Low-iron, fully tempered float glass.
 - 5. Interspace Content: 90% argon.
 - 6. Indoor Lite: Low-iron, fully tempered float glass.
 - 7. Low-E Coating: On second surface.
 - 8. Winter Nighttime U-Factor: 0.28 maximum.
 - 9. Summer Daytime U-Factor: 0.24 maximum.
 - 10. Visible Light Transmittance: 68 percent minimum.
 - 11. SHGC: 0.28 maximum.
 - 12. Safety glazing required.
- B. Low-E-Coated, Tinted Insulating Glass, Type GL-1A:
 - 1. Basis-of-Design Product: Vitro Glazing, Solarban 60 Clear+Clear Optigray.
 - 2. Overall Unit Thickness: 1 inch (25 mm).

3. Minimum Thickness of Each Glass Lite: 6 mm.
4. Outdoor Lite: Heat-strengthened tinted float glass.
5. Interspace Content: 90% argon.
6. Indoor Lite: Heat-strengthened float glass.
7. Low-E Coating: On second surface.
8. Winter Nighttime U-Factor: 0.29 maximum.
9. Summer Daytime U-Factor: 0.24 maximum.
10. Visible Light Transmittance: 50 percent minimum.
11. SHGC: 0.30 maximum.

C. Silicone-Coated, Low-E, Insulating Spandrel Glass, Type GL-2:

1. Basis-of-Design Product: Vitro Glazing, Solarban 72 Clear+Clear with Opti-Coat
2. Coating Color: RAL 7045 TeleGrey
3. Overall Unit Thickness: 1 inch (25 mm).
4. Minimum Thickness of Each Glass Lite: 6 mm.
5. Outdoor Lite: Low-iron, heat-strengthened float glass.
6. Interspace Content: 90% argon.
7. Indoor Lite: Low-iron heat-strengthened float glass.
8. Low-E Coating: On second surface.
9. Opaque Coating Location: Fourth surface.
10. Winter Nighttime U-Factor: 0.28 maximum.
11. Summer Daytime U-Factor: 0.24 maximum.

D. Low-E-Coated, Acid-Etched Obscured Insulating Glass, Type GL-3:

1. Basis-of-Design Product: Vitro Glazing, Solarban 72 Clear+Clear with Walker Textures Satin Acid Etched.
2. Overall Unit Thickness: 1 inch (25 mm).
3. Minimum Thickness of Each Glass Lite: 6 mm.

4. Outdoor Lite: Heat-strengthened acid-etched float glass.
5. Interspace Content: 90% argon.
6. Indoor Lite: Heat-strengthened float glass.
7. Low-E Coating: On third surface.
8. Acid Etch: On second surface
9. Winter Nighttime U-Factor: 0.28 maximum.
10. Summer Daytime U-Factor: 0.24 maximum.

E. Low-E-Coated, Acid-Etched Opaque Insulating Glass, Type GL-4:

1. Basis-of-Design Product: Vitro Glazing, Solarban 72 Clear+Clear with Walker Textures Opaque Acid Etched.
2. Overall Unit Thickness: 1 inch (25 mm).
3. Minimum Thickness of Each Glass Lite: 6 mm.
4. Outdoor Lite: Heat-strengthened acid-etched float glass.
5. Interspace Content: 90% argon.
6. Indoor Lite: Heat-strengthened float glass.
7. Low-E Coating: On third surface.
8. Acid Etch: On second surface
9. Winter Nighttime U-Factor: 0.28 maximum.
10. Summer Daytime U-Factor: 0.24 maximum.

3.08 MONOLITHIC GLASS SCHEDULE

A. Clear Glass, Type GL-5: Fully tempered float glass.

1. Minimum Thickness: 6 mm.
2. Safety glazing required.

END OF SECTION

SECTION 08 91 19

FIXED LOUVERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Fixed extruded-aluminum louvers for in-wall louvers and louver screen walls.
2. Fixed acoustical louvers.

1.02 DEFINITIONS

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
- B. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).
- C. Vertical Louver: Louver with vertical blades (i.e., the axis of the blades are vertical).
- D. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.
- E. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing in accordance with AMCA 500-L.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
2. Show mullion profiles and locations.
3. Show locations and attachments of insect screens and blank-off panels.

- 4. Show locations and attachments of gate hardware.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.
- E. Delegated Design Submittal: For louvers indicated to comply with structural and seismic performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Based on evaluation of comprehensive tests performed in accordance with AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.
- B. Sample Warranties: For manufacturer's special warranties.

1.05 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
- B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - 1. Build mockup of louver assembly as shown on Drawings, including supports, attachments, and accessories. Refer to Section 01 43 39 "Mockups."
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.

1.06 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.07 WARRANTY

- A. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of baked enamel, powder coat, or organic finishes within specified warranty period.
 - 1. Deterioration includes, but is not limited to, the following:

- a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Warranty Period: 20 years from date of Substantial Completion

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain fixed louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.02 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design louvers, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.
- B. Structural Performance: Louvers withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures are considered to act normal to the face of the building.
 - 1. Wind Loads:
 - a. Determine loads based on pressures as indicated on Drawings.
- C. Seismic Performance:
 - 1. As indicated on Drawings.
 - 2. Louvers, including attachments to other construction, withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
- D. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 500-L.
- E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

F. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.03 FIXED EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Wind-Driven-Rain-Resistant Louver, Extruded Aluminum:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Construction Specialties RSH-5700 or comparable product by one of the following:
 - a. Airolite Company, LLC (The).
 - b. Greenheck Fan Corporation.
 - c. Reliable Products, Inc.
 - d. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
2. Louver Depth: 5 inches (127 mm).
3. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm).
4. Louver Performance Ratings:
 - a. Free Area: Not less than 7.32 sq. ft. (0.68 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - b. Air Performance: Not more than 0.10-inch wg (25-Pa) static pressure drop at 700-fpm (3.6-m/s) free-area exhaust velocity.
 - c. Wind-Driven Rain Performance: Not less than 99 percent effectiveness when subjected to a rainfall rate of 3 inches (75 mm) per hour and a wind speed of 29 mph (13 m/s) at a core-area intake velocity of 500 fpm (2.5 m/s).
5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.04 FIXED ACOUSTICAL LOUVERS

- A. Acoustic Performance: Provide acoustical louvers complying with ratings specified, as demonstrated by testing manufacturer's stock units identical to those specified.
- B. Fixed, Acoustical Louver, Formed Metal: Louver with formed-metal blades filled on interior with mineral-fiber, rigid-board, acoustical insulation retained by perforated metal sheet of same material and finish as blade.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.; ACL845 or a comparable product by one of the following:
 - a. Airolite Company, LLC (The).
 - b. Construction Specialties, Inc.
 - c. Greenheck Fan Corporation.
2. Louver Depth: 8 inches (200 mm).
3. Frame Material: Extruded aluminum or aluminum sheet, not less than 0.080-inch (2.03-mm) nominal thickness.
4. Blade Material: Aluminum sheet, not less than 0.080-inch (2.03-mm) nominal thickness.
5. Blade Shape: Straight.
6. Blade Angle: 45 degrees unless otherwise indicated.
7. Blade Spacing: 8 inches (200 mm) o.c. for 8-inch- (200-mm-) deep louvers.
8. Free Area: Not less than 4 sq. ft. (0.37 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
9. Airborne Sound-Transmission Loss: STC 10 in accordance with ASTM E413, determined by testing in accordance with ASTM E90.
10. Outdoor-Indoor, Sound-Transmission Loss: OITC 10 in accordance with ASTM E1332, determined by testing in accordance with ASTM E966.

2.05 LOUVER SCREENS

- A. General: Provide screen at each exterior louver.
 1. Screen Location for Fixed Louvers: Interior face.
 2. Screening Type: Bird screening.
- B. Secure screen frames to louver frames with stainless steel machine screws, spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
 1. Metal: Same type and form of metal as indicated for louver to which screens are attached.

2. Finish: Same finish as louver frames to which louver screens are attached.

D. Louver Screening for Aluminum Louvers:

1. Bird Screening, Stainless Steel: 1/2-inch- (13-mm-) square mesh, 0.047-inch (1.19-mm) wire.

2.06 BLANK-OFF PANELS

A. Insulated Blank-Off Panels: Laminated panels consisting of an insulating core surfaced on back and front with metal sheets and attached to back of louver.

1. Thickness: 2 inches (50 mm).
2. Metal Facing Sheets, Aluminum: Not less than 0.032-inch (0.81-mm) nominal thickness.
3. Insulating Core: Rigid, glass-fiber-board insulation or extruded-polystyrene foam.
4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than 0.080-inch (2.03-mm) nominal thickness, with corners mitered and with same finish as panels.
5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
6. Panel Finish: Same finish applied to adjacent louvers.

2.07 LOUVER SCREEN WALL GATE HARDWARE

A. Hardware:

1. Provide exterior grade hardware including levers and latches permitting operation from both sides of gate, hinges, and locks for each gate shown.
2. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.
 - a. Function: Full surface, triple weight, antifriction bearing.
 - b. Material: Wrought steel, forged steel, cast steel, or malleable iron; galvanized.
3. Rim Locks: BHMA A156.5, Grade 1, suitable for exterior use.
 - a. Function: Latchbolt by key from outside and by turn from inside. Latchbolt is held retracted by device from inside.
 - b. Material: Cast, forged, or extruded brass or bronze.

- c. Mounting Plate: Configuration necessary for mounting locks. Fabricate from 1/8-inch- (3.2-mm-) thick, aluminum plate.
- d. Coordinate keying with section 08 71 00 "Door Hardware"

2.08 MATERIALS

- A. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5, T-52, or T6.
- B. Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.
- C. Fasteners: Use types and sizes to suit unit installation conditions.
 - 1. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.
 - 2. For fastening aluminum, use aluminum or 300 series stainless steel fasteners.
 - 3. For fastening stainless steel, use 300 series stainless steel fasteners.
 - 4. For color-finished louvers, use fasteners with heads that match color of louvers.
- D. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless steel components, with allowable load or strength design capacities calculated in accordance with ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing in accordance with ASTM E488/E488M conducted by a qualified testing agency.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.09 FABRICATION

- A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
- B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
- C. Maintain equal louver blade spacing to produce uniform appearance.
- D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- E. Include supports, anchorages, and accessories required for complete assembly.

- F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.
 - 1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
 - 2. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.
- G. Join frame members to each other and to fixed louver blades with fillet welds concealed from view unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.10 ALUMINUM FINISHES

- A. Finish louvers after assembly.
- B. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- D. Finish Systems: Refer to Drawings for finish locations and colors.
 - 1. Fluoropolymer Two-Coat System: 0.2-mil primer with 0.8-mil 70 percent PVDF fluoropolymer color coat, AAMA 620.
 - 2. Fluoropolymer Three Coat System: 0.65 mil color base coat and Primer with a 0.05 mil PVDF ink coat and a 0.45 nominal PVDF fluoropolymer clear coat.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.03 INSTALLATION

- A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 07 92 00 "Joint Sealants" for sealants applied during louver installation.
- G. Install gates level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.04 ADJUSTING AND CLEANING

- A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- B. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- D. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Engineer, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION

SECTION 09 21 16.23

GYPSUM BOARD SHAFT WALL ASSEMBLIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Gypsum board shaft wall assemblies.

1.02 ACTION SUBMITTALS

- ###### A. Product Data:
- For each component of gypsum board shaft wall assembly.

1.03 DELIVERY, STORAGE, AND HANDLING

- ###### A.
- Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and support them on risers on a flat platform to prevent sagging.

1.04 FIELD CONDITIONS

- ###### A. Environmental Limitations:
- Comply with gypsum-shaftliner-board manufacturer's written instructions.
- ###### B.
- Do not install finish panels until installation areas are enclosed and conditioned.
- ###### C.
- Do not install panels that are wet, moisture damaged, or mold damaged.
1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- ###### A. Fire-Resistance-Rated Assemblies:
- For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing agency.

2.02 GYPSUM BOARD SHAFT WALL ASSEMBLIES

- A. Fire-Resistance Rating: As indicated on Drawings.
- B. Gypsum Shaftliner Board:
 - 1. Type X: ASTM C1396/C1396M; manufacturer's proprietary fire-resistive liner panels with paper faces, 1 inch (25.4 mm) thick, with double beveled long edges.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - (1) American Gypsum.
 - (2) CertainTeed; SAINT-GOBAIN.
 - (3) Continental Building Products Inc.
 - (4) USG Corporation.
- C. Non-Load-Bearing Steel Framing, General: Complying with ASTM C645 requirements for metal unless otherwise indicated and complying with requirements for fire-resistance-rated assembly indicated.
 - 1. Protective Coating: Coating with equivalent corrosion resistance of ASTM A653/A653M, G40 (Z120) unless otherwise indicated.
- D. Studs: Manufacturer's standard profile for repetitive, corner, and end members as follows:
 - 1. Depth: As indicated.
 - 2. Minimum Base-Metal Thickness: 0.018 inch (0.45 mm).
- E. Runner Tracks: Manufacturer's standard J-profile track with manufacturer's standard long-leg length, but at least 2 inches (51 mm) long and matching studs in depth.
 - 1. Minimum Base-Metal Thickness: Matching steel studs.
- F. Finish Panels: Gypsum board as specified in Section 09 29 00 "Gypsum Board."
- G. Sound Attenuation Blankets: As specified in Section 09 29 00 "Gypsum Board."

2.03 AUXILIARY MATERIALS

- A. Provide auxiliary materials that comply with shaft wall manufacturer's written instructions.

- B. Trim Accessories: Cornerbead, edge trim, and control joints of material and shapes as specified in Section 09 29 00 "Gypsum Board" that comply with gypsum board shaft wall assembly manufacturer's written instructions for application indicated.
- C. Steel Drill Screws: ASTM C1002 unless otherwise indicated.
- D. Track Fasteners: Power-driven fasteners of size and material required to withstand loading conditions imposed on shaft wall assemblies without exceeding allowable design stress of track, fasteners, or structural substrates in which anchors are embedded.
 - 1. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E488/E488M conducted by a qualified testing agency.
 - 2. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E1190 conducted by a qualified testing agency.
- E. Acoustical Sealant: Section 07 92 19 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Install gypsum board shaft wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated and manufacturer's written installation instructions.
- B. Do not bridge building expansion joints with shaft wall assemblies; frame both sides of expansion joints with furring and other support.
- C. Install supplementary framing in gypsum board shaft wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, wall-mounted door stops, and similar items that cannot be supported directly by shaft wall assembly framing.

- D. Penetrations: At penetrations in shaft wall, maintain fire-resistance rating of shaft wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons and floor indicators, and similar items.
- E. Isolate perimeter of gypsum panels from building structure to prevent cracking of panels while maintaining continuity of fire-rated construction.
- F. Control Joints: Install control joints according to ASTM C840 and in specific locations approved by Engineer while maintaining fire-resistance rating of gypsum board shaft wall assemblies.
- G. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

3.03 PROTECTION

- A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- B. Remove and replace panels that are wet, moisture damaged, or mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

SECTION 09 22 16

NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Framing systems.
2. Suspension systems.
3. Acoustic isolation materials
4. Partition closures.

B. Related Requirements:

1. Section 05 40 00 "Cold-Formed Metal Framing" for exterior and interior load-bearing and exterior non-load-bearing wall studs; floor joists; and roof rafters and ceiling joists.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Framing systems.
2. Suspension systems.
3. Partition closures.
4. Acoustic isolation materials.
 - a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

1.03 INFORMATIONAL SUBMITTALS

- ###### A. Product Certificates:
- For each type of code-compliance certification for studs and tracks.

- B. Evaluation Reports: For high-strength steel studs and tracks, firestop tracks, post-installed anchors, and power-actuated fasteners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.04 QUALITY ASSURANCE

- A. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association, the Steel Framing Industry Association, the Steel Stud Manufacturers Association, or the Supreme Steel Framing System Association.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Notify manufacturer of damaged materials received prior to installation.
- B. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- C. Protect cold-formed metal framing from corrosion, deformation, and other damage during delivery, storage, and handling as required by AISI S202, "Code of Standard Practice for Cold-Formed Steel Structural Framing."

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated, in accordance with ASTM E119 by an independent testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.
- C. Horizontal Deflection: For wall assemblies, limited to 1/360 of the wall height based on horizontal loading of 5 lbf/sq. ft. (239 Pa).
- D. Design framing systems in accordance with AISI S220, "North American Specification for the Design of Cold-Formed Steel Framing - Nonstructural Members," unless otherwise indicated.

2.02 FRAMING SYSTEMS

- A. Framing Members, General: Comply with ASTM C645 for conditions indicated.
 - 1. Steel Sheet Components: Comply with ASTM C645 requirements for metal unless otherwise indicated

2. Protective Coating: Comply with ASTM C645; ASTM A653/A653M, G40 (Z120); or coating with equivalent corrosion resistance. Galvannealed products are unacceptable.
 - a. Coating demonstrates equivalent corrosion resistance with an evaluation report acceptable to authorities having jurisdiction.
- B. Studs and Track: ASTM C645.
 1. Minimum Base-Steel Thickness: As required by performance requirements for horizontal deflection, but no less than 20 gauge.
 2. Depth: As indicated on Drawings.
- C. High-Strength Steel Studs and Tracks: Roll-formed with surface deformations to stiffen the framing members.
 1. Minimum Base-Steel Thickness: As required by horizontal deflection performance requirements.
 2. Depth: As indicated on Drawings.
- D. Slip-Type Head Joints: Where indicated, provide one of the following:
 1. Single Long-Leg Track System: Top track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top track and with continuous bridging located within 12 inches (305 mm) of the top of studs to provide lateral bracing.
 2. Double-Track System: Top outer tracks, inside track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs and fastened to studs, and outer track sized to friction-fit over inner track.
 3. Deflection Track: Steel sheet top track manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.
- E. Firestop Tracks: Top track manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
- F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
 1. Minimum Base-Steel Thickness: 0.0179 inch (0.455 mm).

G. Cold-Rolled Channel Bridging: Steel, 0.0538-inch (1.367-mm) minimum base-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.

1. Depth: 1-1/2 inches (38 mm).
2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches (38 by 38 mm), 0.068-inch- (1.72-mm-) thick, galvanized steel.

H. Hat-Shaped, Rigid Furring Channels:

1. Minimum Base-Steel Thickness: 0.0179 inch (0.455 mm).
2. Depth: As indicated on Drawings.

2.03 SUSPENSION SYSTEMS

A. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

B. Hanger Attachments to Concrete:

1. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01 or AC193 as appropriate for the substrate.
 - a. Uses: Securing hangers to structure.
 - b. Type: Torque-controlled, expansion anchor.
 - c. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941 (ASTM F1941M), Class Fe/Zn 5, unless otherwise indicated.
 - d. Material for Exterior or Interior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless steel bolts, ASTM F593 (ASTM F738M), and nuts, ASTM F594 (ASTM F836M).
2. Power-Actuated Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

C. Wire Hangers: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.16 inch (4.12 mm) in diameter.

D. Carrying Channels (Main Runners): Cold-rolled, commercial-steel sheet with a base-steel thickness of 0.0538 inch (1.367 mm) and minimum 1/2-inch- (13-mm-) wide flanges.

1. Depth: As indicated on Drawings.

E. Furring Channels (Furring Members):

1. Cold-Rolled Channels: 0.0538-inch (1.367-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges, 3/4 inch (19 mm) deep.
2. Steel Studs and Tracks:
 - a. Minimum Base-Steel Thickness: 0.0179 inch (0.455 mm).
 - b. Depth: As indicated on Drawings.
3. High-Strength Steel Studs and Tracks:
 - a. Minimum Base-Steel Thickness: 0.0147 inch (0.373 mm).
 - b. Depth: As indicated on Drawings.
4. Hat-Shaped, Rigid Furring Channels: 7/8 inch (22 mm) deep.
 - a. Minimum Base-Steel Thickness: 0.0179 inch (0.455 mm).
5. Resilient Furring Channels: 1/2-inch- (13-mm-) deep members designed to reduce sound transmission.
 - a. Configuration: Asymmetrical or hat shaped.

2.04 ACOUSTIC ISOLATION MATERIALS

- A. Resilient Sway Brace: Fail-safe double acting neoprene elements incorporated into an 11 ga. galvanized steel bracket.

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Mason Industries, Inc., Type DNSB; www.mason-industries.com
 - b. Kinetics Noise Control, Inc., Type PSB; www.kineticsnoise.com
 - c. PAC International, RSIC-CWB; www.pac-intl.com
 - d. Equal as approved by Engineer.
2. Neoprene shall be 60 durometer, and meet the following physical requirements:

a. Hardness (ASTM D-676)	60 ± 5
b. Tensile strength, minimum psi (ASTM D-412)	2,500
c. Elongation at break, minimum percent	350

3. Isolator shall be selected upon ability to satisfy a maximum response frequency of 10 Hz for the composite wall/isolator construction. Manufacturer shall submit calculations of loads, isolator spacing, and connection details for approval.
- B. Resilient Low-Profile Sway Brace: Galvanized steel brackets interlocked with a neoprene noise and vibration insert. Shall contain two 1/4" diameter thru-holes to permit use of fasteners to attach braces to studs.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Mason Industries, Inc., Type WIC; www.mason-industries.com
 - b. Kinetics Noise Control, Inc., Type KWSB; www.kineticsnoise.com
 - c. Equal as approved by Engineer.
 2. Isolator shall be selected upon ability to satisfy a maximum response frequency of 10 Hz for the composite wall/isolator construction. Manufacturer shall submit calculations of loads, isolator spacing, and connection details for approval.
- C. Top and Bottom Track Isolators: Resilient partition isolation pad used along entire length of track or at connection locations. Shall resiliently decouple sound-rated partition from non-isolated structure.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Mason Industries, Inc., Type NPS; www.mason-industries.com
 - b. Kinetics Noise Control, Inc., Wallmat and KAI; www.kineticsnoise.com
 - c. Equal as approved by Engineer.
 2. For bottom track, provide unit engineered for project's studwall load.
- D. Suspended Acoustical Ceiling Spring Hanger
1. The sound isolation materials specified herein shall be designed and manufactured by Kinetics Noise Control, Inc.
 2. Resilient hangers shall have sufficient capacity to sustain continuously applied ceiling weight without settling after initial deflection. The isolation hanger shall be a combination high-deflection steel spring in series with a resilient, molded neoprene noise and vibration isolation pad. The steel spring and neoprene pad shall be incorporated into a stamped steel hanger assembly that resiliently supports the isolated ceiling.
 3. The hanger assembly bracket shall be designed to allow fifteen (15) degrees of vertical alignment of the suspension member without making metal-to-metal contact between the suspension and hanger assembly members. The hanger bracket shall be

designed with an integral spring pre-load bracket selected to minimize change in elevation once a load is applied to the hanger and to hold the isolator assembly steady during attachment of gypsum board. The hanger assembly bracket shall consist of a leveling rod with an attached channel carrier designed to accept 1-1/2" x 1/2", 16-gauge cold-rolled steel. The isolation hanger deflection shall be selected by the manufacturer to provide a maximum natural frequency of 4.4 Hz. The steel spring element shall have a minimum Kx to Ky of 1 at its 1" rated deflection.

2.05 PARTITION CLOSURES

- A. Extruded Aluminum Partition Closures: Pre-assembled, spring loaded to provide a tight fit for vertical junctures of partitions and window walls.
 - 1. Aluminum Extrusions: 6063-T5 temper, tensile strength 31 KSI.
 - 2. Size: As shown on Drawings.
 - 3. Finish: Acrylic-Polyester hybrid powder coat paint finish.
 - a. Color: As selected by Engineer.
 - 4. Sound tested to a composite STC of 35 with acoustical batts for sound attenuation.
 - 5. Provide end caps where shown.
 - 6. Equal to Gordon Industries, Mullion Mate Series 30.

2.06 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials that comply with referenced installation standards.
 - 1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.
- B. Isolation Strip at Exterior Walls: Provide the following:
 - 1. Asphalt-Saturated Organic Felt: ASTM D226/D226M, Type I (No. 15 asphalt felt), nonperforated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 COORDINATION

- A. For spaces where acoustic isolators have been included there shall be no direct or indirect rigid connections between the isolated wall assembly/framing and the adjacent construction.

3.03 PREPARATION

- A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.
 - 1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.

3.04 INSTALLATION, GENERAL

- A. Installation Standard: ASTM C754.
 - 1. Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.
- B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.
- C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.
- D. Install bracing at terminations in assemblies.
- E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.05 INSTALLATION OF FRAMING SYSTEMS

- A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
 - 1. As required by horizontal deflection performance requirements unless otherwise indicated.
- B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.
- C. Install studs so flanges within framing system point in same direction.
- D. Install tracks at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated to

terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.

1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.
 - a. Install two studs at each jamb unless otherwise indicated.
 - b. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.
3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
 - a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.

E. Direct Furring:

1. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.

F. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

3.06 INSTALLATION OF SUSPENSION SYSTEMS

A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

1. Hangers: 48 inches (1219 mm) o.c.
2. Carrying Channels (Main Runners): 48 inches (1219 mm) o.c.
3. Furring Channels (Furring Members): 16 inches (406 mm) o.c.

B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

C. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.

a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.

3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.

4. Do not attach hangers to steel roof deck.

5. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.

6. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.

7. Do not connect or suspend steel framing from ducts, pipes, or conduit.

D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

E. Seismic Bracing: Sway-brace suspension systems with hangers used for support.

3.07 INSTALLING ACOUSTIC ISOLATION MATERIALS

A. Ensure that installation complies with the Manufacturer's written instructions and all applicable Code Requirements.

3.08 FIELD QUALITY CONTROL

A. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet (3 mm in 3.6 m) measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION

SECTION 09 29 00

GYPSUM BOARD

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Interior gypsum board.
2. Tile backing panels.

B. Related Requirements:

1. Section 06 16 00 "Sheathing" for gypsum sheathing for exterior walls.
2. Section 07 92 19 "Acoustical Joint Sealants" for acoustical joint sealants installed in gypsum board assemblies.
3. Section 09 22 16 "Non-Structural Metal Framing" for non-structural steel framing and suspension systems that support gypsum board panels.

1.02 ACTION SUBMITTALS

A. Product Data: For each product specified.

B. Shop Drawings: Show locations and installation of control and expansion joints, including plans, elevations, sections, details of components, and attachments to other work.

1.03 DELIVERY, STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.04 FIELD CONDITIONS

A. Environmental Limitations: Comply with ASTM C840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.

B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, moisture damaged, and mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain each type of gypsum panel and joint finishing material from single source with resources to provide products of consistent quality in appearance and physical properties.

2.02 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated in accordance with ASTM E119 by an independent testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.

2.03 GYPSUM BOARD, GENERAL

- A. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.04 INTERIOR GYPSUM BOARD

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. American Gypsum.
 2. CertainTeed; SAINT-GOBAIN.
 3. Continental Building Products Inc.
 4. Gold Bond Building Products, LLC provided by National Gypsum Company.
 5. PABCO Gypsum.
- B. Gypsum Wallboard: ASTM C1396/C1396M.
 1. Thickness: As indicated on Drawings

2. Long Edges: Tapered.
- C. Gypsum Board, Type X: ASTM C1396/C1396M.
 1. Thickness: 5/8 inch (15.9 mm).
 2. Long Edges: Tapered.
- D. Gypsum Ceiling Board: ASTM C1396/C1396M.
 1. Thickness: 1/2 inch (12.7 mm).
 2. Long Edges: Tapered.

2.05 SPECIALTY GYPSUM BOARD

- A. Acoustically Enhanced Gypsum Board: ASTM C1766. Multilayer products constructed of two layers of gypsum boards sandwiching a viscoelastic sound-absorbing polymer core.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed; SAINT-GOBAIN.
 - b. Gold Bond Building Products, LLC provided by National Gypsum Company.
 - c. PABCO Gypsum.
 - d. Panel Rey.
 2. Core: 1/2 inch (12.7 mm), regular type.
 3. Long Edges: Tapered.
 4. Mold Resistance: ASTM D3273, score of 10 (no mold growth) as rated in accordance with ASTM D3274.
 5. Surface Abrasion: ASTM C1629/C1629M, complies with or exceeds Level 1 requirements.
 6. Indentation: ASTM C1629/C1629M, complies with or exceeds Level 1 requirements.
 7. Soft-Body Impact: ASTM C1629/C1629M, complies with or exceeds Level 1 requirements.

2.06 TILE BACKING PANELS

- A. Cementitious Backer Units: ANSI A118.9 and ASTM C1288 or ASTM C1325, with manufacturer's standard edges.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed; SAINT-GOBAIN.
 - b. Custom Building Products.
 - c. PermaBASE Building Products, LLC provided by National Gypsum Company.
 - d. USG Corporation.
 - 2. Thickness: 1/2 inch (12.7 mm).
 - 3. Mold Resistance: ASTM D3273, score of 10 as rated in accordance with ASTM D3274.

2.07 TRIM ACCESSORIES

- A. Interior Trim: ASTM C1047.
 - 1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.

2.08 JOINT TREATMENT MATERIALS

- A. General: Comply with ASTM C475/C475M.
- B. Joint Tape:
 - 1. Interior Gypsum Board: Paper.
 - 2. Tile Backing Panels: As recommended by panel manufacturer.
- C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.
 - 1. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.
 - 2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use drying-type, all-purpose compound.
 - a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.
 4. Finish Coat: For third coat, use drying-type, all-purpose compound.
- D. Joint Compound for Tile Backing Panels:
1. Cementitious Backer Units: As recommended by backer unit manufacturer.

2.09 AUXILIARY MATERIALS

- A. Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.
- B. Steel Drill Screws: ASTM C1002 unless otherwise indicated.
1. Use screws complying with ASTM C954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.
 2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
- C. Sound-Attenuation Blankets: ASTM C665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
- D. Acoustical Sealant: As specified in Section 07 92 19 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION AND FINISHING OF PANELS, GENERAL

- A. Comply with ASTM C840.

- B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.
- D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- E. Form control and expansion joints with space between edges of adjoining gypsum panels.
- F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
 - 1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.
 - 2. Fit gypsum panels around ducts, pipes, and conduits.
 - 3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.
- G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
- I. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C919 and with manufacturer's written instructions for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.
- J. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.03 INSTALLATION OF INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:

1. Wallboard Type: As indicated on Drawings.
2. Type X: Vertical surfaces unless otherwise indicated.
3. Ceiling Type: Ceiling surfaces, unless otherwise indicated.
4. Acoustically Enhanced Type: As indicated on Drawings.

B. Single-Layer Application:

1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.
2. On partitions/walls, apply gypsum panels vertically (parallel to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
 - a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
 - b. At high walls, install panels horizontally unless otherwise indicated or required by fire-resistance-rated assembly.
3. On Z-shaped furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

C. Multilayer Application:

1. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints one framing member, 16 inches (400 mm) minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
2. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
3. Fastening Methods: Fasten base layers and face layers separately to supports with screws.

3.04 INSTALLATION OF TILE BACKING PANELS

- A. Cementitious Backer Units: ANSI A108.11, at locations indicated to receive tile.
- B. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.05 INSTALLATION OF TRIM ACCESSORIES

- A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
- B. Control Joints: Install control joints in accordance with ASTM C840 and in specific locations approved by Engineer for visual effect.
- C. Interior Trim: Install in the following locations:
 - 1. Cornerbead: Use at outside corners.
 - 2. LC-Bead: Use at exposed panel edges.

3.06 FINISHING OF GYPSUM BOARD

- A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
- B. Prefill open joints, rounded or beveled edges, and damaged surface areas.
- C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.
- D. Gypsum Board Finish Levels: Finish panels to levels indicated below and in accordance with ASTM C840:
 - 1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
 - 2. Level 2: Panels that are substrate for tile.
 - 3. Level 3: Not used.
 - 4. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
- E. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.07 PROTECTION

- A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
- B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- C. Remove and replace panels that are wet, moisture damaged, and mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

SECTION 09 30 13

CERAMIC TILING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Porcelain floor tile and base.
2. Glazed ceramic wall tile.
3. Metal transition strips.
4. Waterproof membranes.
5. Crack isolation membranes.

B. Related Requirements:

1. Section 07 92 00 "Joint Sealants" for sealing of expansion, contraction, control, and isolation joints in tile surfaces.
2. Section 09 29 00 "Gypsum Board" for cementitious backer units.

1.02 DEFINITIONS

- A. General: Definitions in the ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.
- B. Face Size: Actual tile size, excluding spacer lugs.
- C. Module Size: Actual tile size plus joint width indicated.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.
- C. Samples for Initial Selection: For tile, grout, and accessories involving color selection.
- D. Samples for Verification:

1. Full-size units of each type and composition of tile and for each color and finish required.
2. Metal transition strips in 6-inch (150-mm) lengths.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Master Grade Certificates: For each shipment, type, and composition of tile, signed by tile manufacturer and Installer.
- C. Product Certificates: For each type of product.
- D. Product Test Reports: For tile-setting and -grouting products.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installer is a Five-Star member of the National Tile Contractors Association or a Trowel of Excellence member of the Tile Contractors' Association of America.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.
- B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.
- D. Store liquid materials in unopened containers and protected from freezing.

1.07 FIELD CONDITIONS

- A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations for Tile: Obtain tile of each type and color or finish from single source or producer.
 - 1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.
- B. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from single manufacturer and each aggregate from single source or producer.
 - 1. Obtain setting and grouting materials, except for unmodified Portland cement and aggregate, from single manufacturer.
 - 2. Obtain waterproof and crack isolation membrane, except for sheet products, from manufacturer of setting and grouting materials.

2.02 PRODUCTS, GENERAL

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
 - 1. Provide tile complying with Standard grade requirements unless otherwise indicated.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.
- C. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.
- D. Mounting: For factory-mounted tile, provide back- or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.

2.03 TILE PRODUCTS

- A. Porcelain Tile Type (T1 and B3): Unglazed.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. American Olean.

- b. Crossville, Inc.
 - c. Daltile Corporation.
- 2. Certification: Tile certified by the Porcelain Tile Certification Agency.
- 3. Face Size: Refer to Drawings.
- 4. Thickness: 5/16 inch.
- 5. Face: Plain with square edges.
- 6. Dynamic Coefficient of Friction: Not less than 0.42.
- 7. Tile Color: As selected by Engineer from manufacturer's full range.
- 8. Grout Color: As selected by Engineer from manufacturer's full range.
- 9. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:
 - a. Cove Base: 6 inches x 12 inches
 - b. External Corners: Cove base corner, 1 inch x 6 inches.
 - c. Internal Corners: Field-buttet square corners.

B. Glazed Wall Tile Type (T2 and T3):

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. American Olean; a brand of Dal-Tile Corporation.
 - b. Crossville, Inc.
 - c. Daltile; a brand of Dal-Tile Corporation.
- 2. Module Size: Refer to Drawings.
- 3. Face Size Variation: Rectified.
- 4. Thickness: 5/16 inch (8 mm).
- 5. Face: Pattern of design indicated, with manufacturer's standard edges.
- 6. Finish: Bright, opaque glaze.

7. Tile Color and Pattern: As selected by Engineer from manufacturer's full range.
8. Grout Color: As selected by Engineer from manufacturer's full range.
9. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:
 - a. Bullnose Cap: Manufacturer's standard size.

2.04 WATERPROOF AND CRACK ISOLATION MEMBRANES

- A. General: Manufacturer's standard product that complies with ANSI A118.10/A118.12 and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.
- B. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Bostik, Inc.; Hydroment GoldPlus.
 - b. C-Cure; Pro-Red Waterproofing Membrane 963.
 - c. Custom Building Products; RedGard Waterproofing and Crack Prevention Membrane.
 - d. Laticrete International, Inc.; Laticrete Hydro Ban.
 - e. MAPEI Corporation; Mapelastic AquaDefense.
 - f. TEC, H. B. Fuller Construction Products Inc.; HydraFlex – Waterproofing Crack Isolation Membrane.

2.05 SETTING MATERIALS

- A. Modified Dry-Set Mortar (Thinset): ANSI A118.4.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ardex Americas.
 - b. Bostik, Inc.
 - c. C-Cure.
 - d. Custom Building Products.

- e. Laticrete International, Inc.
 - f. MAPEI Corporation.
2. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site, or prepackaged, dry-mortar mix combined with liquid-latex additive at Project site.
 3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to the other requirements in ANSI A118.4.

2.06 GROUT MATERIALS

- A. General: Product that is recommended by the manufacturer for the application indicated.
- B. High-Performance Tile Grout: ANSI A118.7.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Bostik, Inc.
 - b. C-Cure.
 - c. Custom Building Products.
 - d. Laticrete International, Inc.
 - e. MAPEI Corporation.
 2. Polymer Type: Dry, redispersible form, prepackaged with other dry ingredients or liquid-latex form for addition to prepackaged dry-grout mix.

2.07 MISCELLANEOUS MATERIALS

- A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.
- B. Metal Transition Strips: profile with sloped exposed surface, 5/32" (4 mm) tall leading edge, integrated trapezoid-perforated anchoring leg, and integrated grout joint spacer.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Schluter Systems L.P.; RENO-U or a comparable product by one of the following:
 - a. Custom Building Products.
 - b. Dural USA, Inc.

2. Material and Finish: Stainless Steel Type 304
 3. Height as required for transition from ceramic tile flooring to resilient tile flooring.
- C. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.
 - D. Floor Sealer: Manufacturer's standard product for sealing grout joints and that does not change color or appearance of grout.
- 2.08 MIXING MORTARS AND GROUT
- A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
 - B. Add materials, water, and additives in accurate proportions.
 - C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
 2. Verify that concrete substrates for tile floors installed with thinset mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
 - a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
 - b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.
 3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.

4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Engineer.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with thinset mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.
- B. Where indicated, prepare substrates to receive waterproof membrane by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot (1:50) toward drains.
- C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

3.03 INSTALLATION OF CERAMIC TILE

- A. Comply with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 series "Specifications for Installation of Ceramic Tile" that are referenced in TCNA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.
 1. For the following installations, follow procedures in the ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:
 - a. Tile floors in wet areas.
 - b. Tile floors consisting of tiles 8 by 8 inches (200 by 200 mm) or larger.
- B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
- C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- D. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.

- E. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.
 - F. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.
 - G. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:
 - 1. Glazed Wall Tile: 1/8 inch (3.2 mm).
 - 2. Porcelain Tile: 1/8 inch (3.2 mm).
 - H. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.
 - 1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
 - I. Metal Transition Strips: Install at locations indicated.
 - J. Floor Sealer: Apply floor sealer to grout joints in tile floors according to floor-sealer manufacturer's written instructions. As soon as floor sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.
- 3.04 INSTALLATION OF WATERPROOF AND CRACK ISOLATION MEMBRANES
- A. Install waterproof membrane to comply with ANSI A108.13/A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.
 - B. Allow membrane to cure and verify by testing that it is watertight before installing tile or setting materials over it.
- 3.05 ADJUSTING AND CLEANING
- A. Remove and replace tile that is damaged or that does not match adjoining tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.
 - B. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.
 - 1. Remove grout residue from tile as soon as possible.
 - 2. Clean grout smears and haze from tile according to tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners

recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3.06 PROTECTION

- A. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.
- B. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
- C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

END OF SECTION

SECTION 09 51 13

ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Acoustical panels.
2. Metal suspension system.
3. Metal edge moldings and trim.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Acoustical panels.
2. Metal suspension system.
3. Metal edge moldings and trim.

B. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of sizes indicated below:

1. Acoustical Panels: Set of 6-inch- (150-mm-) square Samples of each type, color, pattern, and texture.

C. Delegated Design Submittals: For seismic restraints for ceiling systems.

1. Include design calculations for seismic restraints including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension-system members.
2. Structural members to which suspension systems will be attached.
3. Method of attaching hangers to building structure.

- a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.
4. Carrying channels or other supplemental support for hanger-wire attachment where conditions do not permit installation of hanger wires at required spacing.
5. Size and location of initial access modules for acoustical panels.
6. Items penetrating finished ceiling and ceiling-mounted items including the following:
 - a. Lighting fixtures.
 - b. Diffusers.
 - c. Grilles.
 - d. Speakers.
 - e. Sprinklers.
 - f. Access panels.
 - g. Perimeter moldings.
7. Show operation of hinged and sliding components covered by or adjacent to acoustical panels.
8. Minimum Drawing Scale: 1/4 inch = 1 foot (1:48).

B. Qualification Data: For testing agency.

C. Product Test Reports: For each acoustical panel ceiling, for tests performed by a qualified testing agency.

D. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.

E. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Units: Full-size panels equal to 2 percent of quantity installed.
2. Suspension-System Components: Quantity of each exposed component equal to 2 percent of quantity installed.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver acoustical panels, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
- B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

1.07 FIELD CONDITIONS

- A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Source Limitations for Ceiling System: Obtain each type of acoustical ceiling panel and its supporting suspension system from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer licensed in the project's State, to design seismic restraints for ceiling systems.
- B. Seismic Performance: Suspended ceilings to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
- C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 1. Flame-Spread Index: Class A in accordance with ASTM E1264.
 2. Smoke-Developed Index: 50 or less.

2.03 ACOUSTICAL PANELS (CL1)

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Armstrong Ceiling & Wall Solutions.
2. CertainTeed; SAINT-GOBAIN.
3. Rockfon; ROCKWOOL International.
4. USG Corporation.

B. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

C. Classification: Provide panels as follows:

1. Type and Form, Type IV Form 2: Mineral base with membrane-faced overlay; Form 2, water felted.
2. Pattern: E (lightly textured).

D. Light Reflectance (LR): Not less than 0.88.

E. Ceiling Attenuation Class (CAC): Not less than 35.

F. Noise Reduction Coefficient (NRC): Not less than 0.60.

G. Thickness: 3/4 inch (19 mm).

2.04 ACOUSTICAL PANELS (CL2, CL3)

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Armstrong Ceiling & Wall Solutions.
2. CertainTeed; SAINT-GOBAIN.
3. Rockfon; ROCKWOOL International.
4. USG Corporation.

B. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

C. Classification: Provide panels as follows:

1. Type and Form, Type XX: High-density, ceramic- and mineral-base panels with scrubbable finish, resistant to heat, moisture, and corrosive fumes.

- 2. Pattern: CE (perforated, small holes and lightly textured).
- D. Light Reflectance (LR): Not less than 0.79.
- E. Ceiling Attenuation Class (CAC): Not less than 38.
- F. Noise Reduction Coefficient (NRC): Not less than 0.55.
- G. Edge/Joint Detail: Square.
- H. Thickness: 5/8 inch (15 mm).

2.05 METAL SUSPENSION SYSTEM

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Armstrong Ceiling & Wall Solutions; Prelude System or a comparable product by one of the following:
 - 1. CertainTeed; SAINT-GOBAIN.
 - 2. Rockfon; ROCKWOOL International.
 - 3. USG Corporation.
- B. Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, metal suspension system and accessories in accordance with ASTM C635/C635M and designated by type, structural classification, and finish indicated.
- C. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet; prepainted, electrolytically zinc coated, or hot-dip galvanized, G30 (Z90) coating designation; with prefinished 15/16-inch- (24-mm-) wide metal caps on flanges.
 - 1. Structural Classification: Heavy-duty system.
 - 2. Face Design: Flat, flush.
 - 3. Cap Material: aluminum.
 - 4. Cap Finish: Painted white.

2.06 ACCESSORIES

- A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
 - 1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without

failure, a load equal to five times that imposed by ceiling construction, as determined by testing in accordance with ASTM E488/E488M or ASTM E1512 as applicable, conducted by a qualified testing and inspecting agency.

- a. Type: Cast-in-place or Post-installed expansion anchors.
 - b. Corrosion Protection, Stainless Steel: Components complying with ASTM F593 and ASTM F594, Group 1 Alloy 304 or 316.
 - c. Corrosion Protection, Nickel-Copper Alloy: Components fabricated from nickel-copper-alloy rods complying with ASTM B164 for UNS No. N04400 alloy.
2. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing in accordance with ASTM E1190, conducted by a qualified testing and inspecting agency.
- B. Wire Hangers, Braces, and Ties: Provide wires as follows:
1. Stainless Steel Wire: ASTM A580/A580M, Type 304, nonmagnetic.
 2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.106-inch- (2.69-mm-) diameter wire.
- C. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.
- D. Seismic Clips: Manufacturer's standard seismic clips designed to secure acoustical panels in place during a seismic event.
- E. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.
- F. Seismic Struts: Manufacturer's standard compression struts designed to accommodate seismic forces.

2.07 METAL EDGE MOLDINGS AND TRIM

- A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.
1. Edge moldings to fit acoustical panel edge details and suspension systems indicated and match width and configuration of exposed runners unless otherwise indicated.

2. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.

2.08 ACOUSTICAL SEALANT

- A. Acoustical Sealant: As specified in Section 07 92 19 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.
- B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.
- B. Layout openings for penetrations centered on the penetrating items.

3.03 INSTALLATION OF ACOUSTICAL PANEL CEILINGS

- A. Install acoustical panel ceilings in accordance with ASTM C636/C636M, seismic design requirements, and manufacturer's written instructions.
- B. Suspend ceiling hangers from building's structural members and as follows:
 1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
 2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support

standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.

4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
 5. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
 6. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 7. Do not attach hangers to steel deck tabs.
 8. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 9. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 10. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.
- C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.
- D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
1. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends. Miter corners accurately and connect securely.
 2. Do not use exposed fasteners, including pop rivets, on moldings and trim.
- E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide precise fit.

1. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
2. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
3. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
4. Install seismic clips in areas indicated; space in accordance with panel manufacturer's written instructions unless otherwise indicated.

3.04 ERECTION TOLERANCES

- A. Suspended Ceilings: Install main and cross runners level to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m), non-cumulative.
- B. Moldings and Trim: Install moldings and trim to substrate and level with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m), non-cumulative.

3.05 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 1. Periodic inspection during the installation of suspended ceiling grids in accordance with ASCE/SEI 7.
- B. Acoustical panel ceiling hangers, anchors, and fasteners will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.06 CLEANING

- A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.
- B. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 09 65 13

RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Thermoplastic-rubber base.
 - 2. Rubber molding accessories

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples for Initial Selection: For each type of product indicated.
- C. Samples for Verification: For each type of product indicated and for each color, texture, and pattern required in manufacturer's standard-size Samples, but not less than 12 inches (300 mm) long.

1.03 DELIVERY, STORAGE, AND HANDLING

- A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C).

1.04 FIELD CONDITIONS

- A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive resilient products during the following periods:
 - 1. 48 hours before installation.
 - 2. During installation.
 - 3. 48 hours after installation.
- B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).
- C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.01 THERMOPLASTIC-RUBBER BASE

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Armstrong Flooring, Inc.
 - 2. Flexco Corporation.
 - 3. Johnsonite; a Tarkett company.
 - 4. Roppe Corporation; Roppe Holding Company.
- B. Product Standard: ASTM F1861, Type TP (rubber, thermoplastic).
 - 1. Group: I (solid, homogeneous).
- C. Thickness: 0.25 inch (6.35 mm).
- D. Height: 6 inches (152 mm).
- E. Lengths: Cut lengths 48 inches (1219 mm) long or coils in manufacturer's standard length.
- F. Outside Corners: Preformed.
- G. Inside Corners: Job formed.
- H. Colors: Refer to Drawings.

2.02 RUBBER MOLDING ACCESSORY

- A. Manufacturer: Subject to compliance with requirements, provide product by one of the following:
 - 1. Armstrong Flooring, Inc.
 - 2. Flexco Corporation.
 - 3. Johnsonite; a Tarkett company.
 - 4. Roppe Corporation; Roppe Holding Company.
- B. Description:
 - 1. Rubber reducer strip for resilient floor covering transitions at concrete or epoxy flooring.

- 2. Rubber transition strips where carpet and resilient flooring meet.
 - C. Colors and Patterns: As selected by Engineer from Manufacturer's full range.
- 2.03 INSTALLATION MATERIALS
- A. Adhesives: Water-resistant type recommended by resilient-product manufacturer for resilient products and substrate conditions indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
 - 1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Installation of resilient products indicates acceptance of surfaces and conditions.

3.02 PREPARATION

- A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.
- B. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.
- C. Do not install resilient products until materials are the same temperature as space where they are to be installed.
 - 1. At least 48 hours in advance of installation, move resilient products and installation materials into spaces where they will be installed.
- D. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

3.03 RESILIENT BASE INSTALLATION

- A. Comply with manufacturer's written instructions for installing resilient base.
- B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

- C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.
- D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.
- E. Do not stretch resilient base during installation.
- F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.
- G. Preformed Corners: Install preformed corners before installing straight pieces.
- H. Job-Formed Corners:
 - 1. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches (76 mm) in length.
 - a. Miter corners to minimize open joints.

3.04 RESILIENT ACCESSORY INSTALLATION

- A. Comply with manufacturer's written instructions for installing resilient accessories.
- B. Resilient Molding Accessories: Butt to adjacent materials and tightly adhere to substrates throughout length of each piece. Install reducer strips at edges of floor covering that would otherwise be exposed.

3.05 CLEANING AND PROTECTION

- A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.
- B. Perform the following operations immediately after completing resilient-product installation:
 - 1. Remove adhesive and other blemishes from surfaces.
- C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.
- D. Cover resilient products subject to wear and foot traffic until Substantial Completion.

END OF SECTION

SECTION 09 65 19

RESILIENT TILE FLOORING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Solid vinyl floor tile.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of resilient floor tile.

1. Include floor tile layouts, edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.
2. Show details of special patterns.

C. Samples for Initial Selection: For each type of floor tile indicated.

D. Samples for Verification: Full-size units of each color and pattern of floor tile required.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of floor tile to include in maintenance manuals.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are competent in techniques required by manufacturer for floor tile installation and seaming method indicated.

1. Engage an installer who employs workers for this Project who are trained or certified by floor tile manufacturer for installation techniques required.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store floor tile and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not

less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C). Store floor tiles on flat surfaces.

1.07 FIELD CONDITIONS

- A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive floor tile during the following periods:
 - 1. 48 hours before installation.
 - 2. During installation.
 - 3. 48 hours after installation.
- B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).
- C. Close spaces to traffic during floor tile installation.
- D. Close spaces to traffic for 48 hours after floor tile installation.
- E. Install floor tile after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: For resilient floor tile, as determined by testing identical products according to ASTM E648 or NFPA 253 by a qualified testing agency.
 - 1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

2.02 SOLID VINYL FLOOR TILE

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Armstrong Flooring, Inc.
 - 2. Flexco Corporation.
 - 3. Mannington Mills, Inc.
 - 4. Patcraft; a division of Shaw Industries, Inc.
 - 5. Roppe Corporation; Roppe Holding Company.

- 6. Shaw Industries Group, Inc.; Berkshire Hathaway Company.
- B. Tile Standard: ASTM F1700.
 - 1. Class: Class III, Printed Film Vinyl Tile.
 - 2. Type: B, Embossed Surface.
- C. Thickness: 0.120 inch (3.0 mm).
- D. Size: 18 by 18 inches (457 by 457 mm).
- E. Colors and Patterns: Refer to Drawings.

2.03 INSTALLATION MATERIALS

- A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by floor tile manufacturer for applications indicated.
- B. Adhesives: Water-resistant type recommended by floor tile and adhesive manufacturers to suit floor tile and substrate conditions indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
 - 1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor tile.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Prepare substrates according to floor tile manufacturer's written instructions to ensure adhesion of resilient products.
- B. Concrete Substrates: Prepare according to ASTM F710.
 - 1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
 - 2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by floor tile manufacturer. Do not use solvents.

3. Alkalinity and Adhesion Testing: Perform tests recommended by floor tile manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 10 pH.
4. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 8 lb of water/1000 sq. ft. in 24 hours.
 - b. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 95 percent relative humidity level measurement.
- C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.
- D. Do not install floor tiles until materials are the same temperature as space where they are to be installed.
 1. At least 48 hours in advance of installation, move resilient floor tile and installation materials into spaces where they will be installed.
- E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient floor tile.

3.03 FLOOR TILE INSTALLATION

- A. Comply with manufacturer's written instructions for installing floor tile.
- B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.
- C. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.
- D. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.
- E. Extend floor tiles into toe spaces, door reveals, closets, and similar openings. Extend floor tiles to center of door openings.

- F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent marking device.
- G. Adhere floor tiles to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.04 CLEANING AND PROTECTION

- A. Comply with manufacturer's written instructions for cleaning and protecting floor tile.
- B. Perform the following operations immediately after completing floor tile installation:
 - 1. Remove adhesive and other blemishes from surfaces.
 - 2. Sweep and vacuum surfaces thoroughly.
 - 3. Damp-mop surfaces to remove marks and soil.
- C. Protect floor tile from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.
- D. Cover floor tile until Substantial Completion.

END OF SECTION

SECTION 09 67 23
RESINOUS FLOORING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Resinous flooring at Lab (EF1).
2. Integral cove base accessories (B2).

B. Related Requirements:

1. Section 09 96 73 "Coating Systems for Chemical Feed Areas" for resinous flooring (CHEM) used in other locations.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review manufacturer's written instructions for substrate preparation and environmental conditions affecting resinous flooring installation.
2. Review details of integral cove bases.
3. Review manufacturer's written instructions for installing resinous flooring systems.
4. Review protection measures for adjacent construction and installed flooring, floor drainage requirements, curbs, base details, and so forth.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include manufacturer's technical data, installation instructions, and recommendations for each resinous flooring component required.

B. Samples for Initial Selection: For each type of exposed finish required.

C. Samples for Verification: For each resinous flooring system required and for each color and texture specified, 6 inches (150 mm) square, applied to a rigid backing by Installer for this Project.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Material Certificates: For each resinous flooring component.
- C. Material Test Reports: For each resinous flooring system, by a qualified testing agency.
- D. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For resinous flooring to include in maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
 - 1. Engage an installer who is certified in writing by resinous flooring manufacturer as qualified to apply resinous flooring systems indicated.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage and mixing with other components.

1.08 FIELD CONDITIONS

- A. Environmental Limitations: Comply with resinous flooring manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting resinous flooring installation.
- B. Lighting: Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during resinous flooring installation.
- C. Close spaces to traffic during resinous flooring installation and for 24 hours after installation unless manufacturer recommends a longer period.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Flammability: Self-extinguishing in accordance with ASTM D635.

2.02 RESINOUS FLOORING (EF1)

- A. Resinous Flooring System: Abrasion-, impact-, and chemical-resistant, aggregate-filled, resin-based monolithic floor surfacing designed to produce a seamless floor and integral cove base.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Dudick Inc.
 - b. Duraflex, Inc.
 - c. Sherwin-Williams High Performance Flooring.
 - d. Sika Corporation; Flooring.
 - e. Stonhard, Inc.
- B. Source Limitations: Obtain primary resinous flooring materials, including primers, resins, hardening agents, grouting coats, and topcoats, from single source from single manufacturer. Obtain secondary materials, including patching and fill material, joint sealant, and repair materials, of type and from manufacturer recommended in writing by manufacturer of primary materials.
- C. System Characteristics:
 - 1. Color and Pattern: As selected by Engineer from manufacturer's full range.
 - 2. Wearing Surface: Smooth, matte finish.
 - 3. Overall System Thickness: 3/16 inch (4.8 mm).
- D. System Physical Properties: Provide resinous flooring system with the following minimum physical property requirements when tested in accordance with test methods indicated:
 - 1. Compressive Strength: 6000 psi minimum in accordance with ASTM C579.
 - 2. Tensile Strength: 1500 psi minimum in accordance with ASTM C307.
 - 3. Flexural Modulus of Elasticity: 5.0 x 10⁵ psi minimum in accordance with ASTM C580.
 - 4. Impact Resistance: No chipping, cracking, or delamination and not more than 1/16-inch (1.6-mm) permanent indentation in accordance with MIL-D-3134J.
 - 5. Resistance to Elevated Temperature: No slip or flow of more than 1/16 inch (1.6 mm) in accordance with MIL-D-3134J.

6. Abrasion Resistance: 0.06 gm maximum weight loss in accordance with ASTM D4060.
 7. Hardness: 85 to 90, Shore D in accordance with ASTM D2240.
- E. Primer: Type recommended in writing by resinous flooring manufacturer for substrate and resinous flooring system indicated.
1. Material Basis: Stonblend Primer
 2. Resin: Epoxy.
 3. Formulation Description: 2 component, 100% solids.
 4. Type: non pigmented.
 5. Finish: standard.
 6. Number of Coats: one.
- F. Mortar Base:
1. Material Basis: Stonblend Mortar
 2. Resin: Epoxy.
 3. Formulation Description: 3 component, 100% solids.
 4. Application Method: Flat Metal or plastic blade trowel.
 - a. Thickness of Coats: 3/16 inch (5 mm).
 - b. Number of Coats: One.
 5. Aggregates: Pigmented quartz Blended aggregate.
- G. Grout Coat:
1. Material Basis: Stonblend Groutcoat
 2. Resin: Epoxy.
 3. Formulation Description: 2 component, 100% high solids.
 4. Type: Clear.
 5. Finish: standard.
 6. Number of Coats: one.

H. Sealer:

1. Material Basis: Stonkote CE4.
2. Resin: Epoxy
3. Formulation Description: 2 component, 100% solids.
4. Type: Clear.
5. Finish: Matte.
6. Number of Coats: one.

I. Topcoats: Sealing or finish coats.

1. Material Basis: Stonseal CF7.
2. Resin: VOC EPA Compliant, Waterborne, Aliphatic Polyurethane.
3. Formulation Description: 2 component 100% high solids.
4. Type: Clear.
5. Finish: Matte.
6. Number of Coats: Two.

J. Waterproofing Membrane: Type recommended by manufacturer for substrate and primer and body coats indicated.

K. Patching, Leveling and Fill Material: Resinous product of or approved by resinous flooring manufacturer and recommended by manufacturer for application indicated.

L. Joint Sealant: Type recommended or produced by resinous flooring manufacturer for type of service and joint condition indicated.

2.03 INTEGRAL COVE BASE ACCESSORIES

A. Precast, Integral Cove Base: Impact-resistant, polymer-resin, cove base moldings with a grit profile to promote adhesion of resinous flooring and recommended in writing by resinous flooring manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
 - 1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resinous flooring systems.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Prepare and clean substrates in accordance with resinous flooring manufacturer's written instructions for substrate indicated to ensure adhesion.
- B. Concrete Substrates: Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with resinous flooring.
 - 1. Roughen concrete substrates as follows:
 - a. Shot-blast surfaces with an apparatus that abrades the concrete surface, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup.
 - b. Comply with requirements in SSPC-SP 13/NACE No. 6, with a Concrete Surface Profile of 3 or greater in accordance with ICRI Technical Guideline No. 310.2R, unless manufacturer's written instructions are more stringent.
 - 2. Repair damaged and deteriorated concrete in accordance with resinous flooring manufacturer's written instructions.
 - 3. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m) and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 6 lb of water/1000 sq. ft. in 24 hours.
 - b. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 85 percent relative humidity level measurement.

- C. Patching and Filling: Use patching and fill material to fill holes and depressions in substrates in accordance with manufacturer's written instructions.
 - 1. Control Joint Treatment: Treat control joints and other nonmoving substrate cracks to prevent cracks from reflecting through resinous flooring in accordance with manufacturer's written instructions.
- D. Resinous Materials: Mix components and prepare materials in accordance with resinous flooring manufacturer's written instructions.

3.03 INSTALLATION

- A. Apply components of resinous flooring system in accordance with manufacturer's written instructions to produce a uniform, monolithic wearing surface of thickness specified.
 - 1. Coordinate installation of components to provide optimum adhesion of resinous flooring system to substrate, and optimum intercoat adhesion.
 - 2. Cure resinous flooring components in accordance with manufacturer's written instructions. Prevent contamination during installation and curing processes.
 - 3. Expansion and Isolation Joint Treatment: At substrate expansion and isolation joints, comply with resinous flooring manufacturer's written instructions.

3.04 FIELD QUALITY CONTROL

- A. Material Sampling: Owner may, at any time and any number of times during resinous flooring installation, require material samples for testing for compliance with requirements.
 - 1. Owner will engage an independent testing agency to take samples of materials being used. Material samples will be taken, identified, sealed, and certified in presence of Contractor.
 - 2. Testing agency will test samples for compliance with requirements, using applicable referenced testing procedures or, if not referenced, using testing procedures listed in manufacturer's product data.
 - 3. If test results show applied materials do not comply with specified requirements, pay for testing, remove noncomplying materials, prepare surfaces coated with unacceptable materials, and reinstall flooring materials to comply with requirements.
- B. Core Sampling: At Owner's direction and at locations designated by Owner, take one core sample per 1000 sq. ft. (92.9 sq. m) of resinous flooring, or portion of, to verify thickness. For each sample that fails to comply with requirements, take two additional samples. Repair damage caused by coring. Correct deficiencies in installed flooring as indicated by testing.

3.05 PROTECTION

- A. Protect resinous flooring from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by resinous flooring manufacturer.

END OF SECTION

SECTION 09 68 13

TILE CARPETING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Modular carpet tile used for Walk Off Carpet (WK1).

B. Related Requirements:

1. Section 09 65 13 "Resilient Base and Accessories" for resilient wall base and accessories installed with carpet tile.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
2. Include manufacturer's written installation recommendations for each type of substrate.

B. Shop Drawings: For carpet tile installation, plans showing the following:

1. Columns, doorways, enclosing walls or partitions, and locations where cutouts are required in carpet tiles.
2. Carpet tile type, color, and dye lot.
3. Type of subfloor.
4. Type of installation.
5. Pattern of installation.
6. Pattern type, location, and direction.
7. Pile direction.
8. Transition details to other flooring materials.

C. Samples for Initial Selection: For each type of carpet tile.

1. Include Samples of exposed edge, transition, and other accessory stripping involving color or finish selection.
- D. Samples for Verification: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.
 1. Carpet Tile: Full-size Sample.
 2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch- (300-mm-) long Samples.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.
- C. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:
 1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
 2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is certified by the International Certified Floorcovering Installers Association at the Commercial II certification level.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with the Carpet and Rug Institute's CRI 104.

1.07 FIELD CONDITIONS

- A. Comply with the Carpet and Rug Institute's CRI 104 for temperature, humidity, and ventilation limitations.
- B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at levels planned for building occupants during the remainder of the construction period.

- C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.

1.08 WARRANTY

- A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.
 - 1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
 - 2. Failures include, but are not limited to, the following:
 - a. More than 10 percent edge raveling, snags, and runs.
 - b. Dimensional instability.
 - c. Excess static discharge.
 - d. Loss of tuft-bind strength.
 - e. Loss of face fiber.
 - f. Delamination.
 - 3. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 CARPET TILE

- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Bentley Mills, Inc.
 - 2. J&J Flooring Group LLC.
 - 3. Patcraft; a division of Shaw Industries, Inc.
 - 4. Shaw Industries Group, Inc.; Berkshire Hathaway Company.
- C. Color: As selected by Engineer from manufacturer's full range.
- D. Fiber Content: 100 percent polypropylene.

- E. Total Weight: 36 oz./sq. yd. for finished carpet tile.
- F. Backing System: 100 percent SBR rubber.
- G. Size: 18 by 18 inches (457 by 457 mm).
- H. Thickness: 7/16-inch.
- I. Performance Characteristics:
 - 1. Appearance Retention Rating: Severe traffic, 3.5 minimum according to ASTM D7330.
 - 2. Dry Breaking Strength: Not less than 100 lbf (445 N) according to ASTM D2646.
 - 3. Dimensional Tolerance: Within 1/32 inch (0.8 mm) of specified size dimensions, as determined by physical measurement.
 - 4. Dimensional Stability: 0.2 percent or less according to ISO 2551 (Aachen Test).
 - 5. Colorfastness to Crocking: Not less than 4, wet and dry, according to AATCC 165.
 - 6. Electrostatic Propensity: Less than 1.6 kV according to AATCC 134.

2.02 INSTALLATION ACCESSORIES

- A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.
- B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that comply with flammability requirements for installed carpet tile, and are recommended by carpet tile manufacturer for releasable installation.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance.
- B. Examine carpet tile for type, color, pattern, and potential defects.
- C. Concrete Slabs: Verify that finishes comply with requirements specified in Section 03 30 00 "Cast-in-Place Concrete" and that surfaces are free of cracks, ridges, depressions, scale, and foreign deposits.

1. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
 - b. Relative Humidity Test: Using in situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
 - c. Perform additional moisture tests recommended in writing by adhesive and carpet tile manufacturers. Proceed with installation only after substrates pass testing.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. General: Comply with the Carpet and Rug Institute's CRI 104 and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile.
- B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch (3 mm) wide or wider, and protrusions more than 1/32 inch (0.8 mm) unless more stringent requirements are required by manufacturer's written instructions.
- C. Concrete Substrates: Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by adhesive and carpet tile manufacturers.
- D. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.03 INSTALLATION

- A. General: Comply with the Carpet and Rug Institute's CRI 104, Section 10, "Carpet Tile," and with carpet tile manufacturer's written installation instructions.
- B. Installation Method: As recommended in writing by carpet tile manufacturer.
- C. Maintain dye-lot integrity. Do not mix dye lots in same area.

- D. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.
- E. Extend carpet tile into toe spaces, door reveals, open-bottomed obstructions, removable flanges, alcoves, and similar openings.
- F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on carpet tile as marked on subfloor. Use nonpermanent, nonstaining marking device.

3.04 CLEANING AND PROTECTION

- A. Perform the following operations immediately after installing carpet tile:
 - 1. Remove excess adhesive and other surface blemishes using cleaner recommended by carpet tile manufacturer.
 - 2. Remove yarns that protrude from carpet tile surface.
 - 3. Vacuum carpet tile using commercial machine with face-beater element.
- B. Protect installed carpet tile to comply with the Carpet and Rug Institute's CRI 104, Section 13.7.
- C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION

SECTION 09 84 33

SOUND-ABSORBING WALL AND CEILING UNITS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes shop-fabricated, acoustical panel units tested for acoustical performance, including the following:
 - 1. Sound-absorbing wall panels.
 - 2. Sound-absorbing ceiling panels.

1.02 DEFINITIONS

- A. NRC: Noise Reduction Coefficient.
- B. SAA: Sound Absorption Average.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include technical data for panel and mounting indicated.
- B. Shop Drawings: For unit assembly and installation.
 - 1. Include plans, elevations, sections, and mounting devices and details.
 - 2. Include details at cutouts and penetrations for other work.
- C. Samples: Approximately 6 x 6 inches, including mounting methods.

1.04 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of unit.
- B. Sample Warranty: For manufacturer's special warranty.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For each type of unit to include in maintenance manuals. Include manufacturers' written cleaning and stain-removal instructions.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver acoustical ceiling units to project site in original, unopened packages and store them in a fully enclosed space where they will be protected against damage from moisture, direct sunlight, surface contamination, and other causes.
- B. Before installing acoustical ceiling units, permit them to reach room temperature and a stabilized moisture content.
- C. Handle acoustical ceiling units carefully to avoid chipping edges or damaged units in any way.
- D. Provide labels indicating brand name, style, size, and thickness

1.07 FIELD CONDITIONS

- A. Environmental Requirements:
 - 1. Do not install ceiling panels until building is closed in and HVAC system is operational.
 - 2. Locate materials onsite at least 72 hours before beginning installation to allow materials to reach temperature and moisture content equilibrium.
- B. Maintain the following conditions in areas where acoustical materials are to be installed 72 hours before, during, and after installation:
 - 1. Relative Humidity: 25 – 85%
 - 2. Uniform Temperature: 32 – 120 degrees F (0 – 49 degrees C)

1.08 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace units and components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Thirty years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain wall and ceiling units specified in this Section from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: Units shall comply with "Surface-Burning Characteristics" or "Fire Growth Contribution" Subparagraph below, or both, as determined by testing identical products by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
1. Surface-Burning Characteristics: Comply with ASTM E84 or UL 723; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 450 or less.

2.03 SOUND-ABSORBING WALL AND CEILING UNITS

- A. Sound-Absorbing Wall Panel:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Armstrong Ceiling & Wall Solutions; TECTUM FINALE Wall Panels and TECTUM FINALE Ceiling Panels or a comparable product by one of the following:
 - a. Acoustical Surfaces, Inc.
 - b. Cardinal Acoustics.
 2. Surface Texture: Coarse
 3. Composition: Aspen wood fibers bonded with inorganic hydraulic cement
 4. Finish: Surface appearance shall be consistent from panel to panel. Factory-applied latex paint with Sodium Silicate surface coating for abuse resistance.
 5. Color: Custom color as selected by Engineer.
 6. Size: As required and as shown on the Contract Drawings.
 7. Thickness: Standard 1-inch facing material plus 1-inch integral furring
 8. Edge Profile: Bevel on long edges, square on short sides
 9. Noise Reduction Coefficient (NRC) ASTM C 423: D-20 Mounting – 0.95
 10. Dimensional Stability / Mold Resistance: HumiGuard Plus and no significant mold growth when tested by ASTM D 3273.

- B. Mounting Devices: Concealed on back of unit, manufacturer's standard concealed devices to support weight of unit, and to achieve specified NRC value. Ceiling units may be direct mounted via furring strips to roof deck.

2.04 FABRICATION

- A. Standard Construction: Use manufacturer's standard construction unless otherwise indicated; dimensionally stable panels and with rigid edges to reinforce panel perimeter against warpage and damage.
- B. Dimensional Tolerances of Finished Units: Plus or minus 1/16 inch (1.6 mm) for the following:
 - 1. Thickness.
 - 2. Edge straightness.
 - 3. Overall length and width.
 - 4. Squareness from corner to corner.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine fabric, fabricated units, substrates, areas, and conditions for compliance with requirements, installation tolerances, and other conditions affecting unit performance.
- B. Do not proceed with installation until all wet work such as concrete and painting has been completed and thoroughly dried out, unless expressly permitted by manufacturer's printed recommendations.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Measure each wall and ceiling area and establish layout of acoustical units. Coordinate panel layout with mechanical and electrical fixtures.
- B. Coordination: Furnish layouts for preset inserts, clips, and other ceiling anchors whose installation is specified in other sections.
 - 1. Furnish concrete inserts and similar devices to other trades for installation well in advance of time needed for coordination of other work.

3.03 INSTALLATION

- A. Install units in locations indicated.

- B. Comply with manufacturer's written instructions for installation of units using type of mounting devices indicated. Mount units securely to supporting substrate.

3.04 ADJUSTING AND CLEANING

- A. Replace damaged and broken panels.
- B. Clean exposed surfaces of acoustical ceilings including trim, edge moldings, and suspension members. Comply with manufacturer's instructions for cleaning and touch up of minor finish damage. Remove any panels that cannot be successfully cleaned and/or repaired. Replace with attic stock or new product to eliminate evidence of damage.
- C. Cleaning and Disinfecting Guidelines
 1. It is recommended that only clear cleaners be used, as dyed liquids can permanently discolor the finish of the ceiling tiles.
 2. Cleaning is only recommended for the finished face of the board.
 3. Panels should never be soaked in water or other liquids, as this can have an adverse effect on board integrity. Use the safety recommendations for gloves and eye protection that are given by the manufacturer of the cleaner and cleaning equipment.

3.05 INSTALLATION TOLERANCES

- A. Variation from Plumb and Level: Plus or minus 1/16 inch (1.6 mm) in 48 inches (1200 mm), noncumulative.

3.06 CLEANING

- A. Clip loose threads; remove pills and extraneous materials.
- B. Clean panels on completion of installation to remove dust and other foreign materials according to manufacturer's written instructions.

END OF SECTION

SECTION 09 91 23
INTERIOR PAINTING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes interior paint systems at the Administration Building.
- B. Related Requirements:
 - 1. Section 09 96 00 "High-Performance Coatings" for tile-like coatings and paints used in the process and pump station buildings.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
 - 1. Include preparation requirements and application instructions.
 - 2. Indicate VOC content.
- B. Samples for Verification: For each type of paint system and each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
 - 2. Apply coats on Samples in steps to show each coat required for system.
 - 3. Label each coat of each Sample.
 - 4. Label each Sample for location and application area.
- C. Product Schedule: Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

1.03 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Paint Products: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver materials to the job site in the manufacturer's original, unopened packages and containers bearing manufacturer's name and label and the following information:
 - 1. Product name or title of material.
 - 2. Product description (generic classification or binder type).
 - 3. Manufacturer's stock number and date of manufacturer.
 - 4. Contents by volume, for pigment and vehicle constituents.
 - 5. Thinning instructions.
 - 6. Application instructions.
 - 7. Color name and number.
- B. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.05 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures of less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Sherwin-Williams Company (The).
 - 2. Manufacturer as approved by Owner.
- B. Source Limitations: Obtain each paint product from single source from single manufacturer.

2.02 PAINT PRODUCTS, GENERAL

A. General:

1. Use only one manufacturer's products within a paint system. Do not intermix or thin one product line with another.
2. Provide pure, nonfading color pigments of the type and quality to suit substrates and service indicated.

B. Material Compatibility:

1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

C. Paint Coordination:

1. Provide finish coats compatible with prime coats used. Review other Sections of these Specifications for compatibility of total coatings system.
2. Upon request from other trades, furnish information on characteristics of proposed finish materials to ensure compatible prime coats.
3. Provide barrier coats over incompatible primers or remove and re-prime as required to provide a proper paint system.
4. Notify Engineer in writing of any anticipated problems using specified coating systems with surfaces shop-primed by others.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 1. Masonry (Clay and CMUs): 12 percent.
 2. Gypsum Board: 12 percent.

- C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.
- E. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.02 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations applicable to substrates and paint systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.
- E. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer.
- F. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- G. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

3.03 INSTALLATION

- A. Apply paints according to manufacturer's written instructions.
 - 1. Use applicators and techniques suited for paint and substrate indicated.

2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- 3.04 FIELD QUALITY CONTROL
- A. Dry-Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry-film thickness.
1. Contractor shall touch up and restore painted surfaces damaged by testing.
 2. If test results show that dry-film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry-film thickness that complies with paint manufacturer's written recommendations.
- 3.05 CLEANING AND PROTECTION
- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
1. Do not clean equipment with free-draining water and prevent solvents, thinners, cleaners, and other contaminants from entering into waterways, sanitary and storm drain systems, and ground.
 2. Dispose of contaminants in accordance with requirements of authorities having jurisdiction.

3. Allow empty paint cans to dry before disposal.
 4. Collect waste paint by type and deliver to recycling or collection facility.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Engineer, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.06 INTERIOR PAINTING SCHEDULE

- A. Gypsum Board Walls – Low-Odor/Low VOC:
1. Primer: 1 coat ProMar 200 Zero VOC Latex Primer
 2. Finish: 2 coats S-W Pre-Catalyzed Epoxy Eg-Shel
- B. Exposed Construction at Ceilings and Gypsum Board Ceilings - Low-Odor/Low VOC:
1. Surface Preparation: All surfaces must be smooth and clean.
 2. Finish: 2 coats S-W ProIndustrial Acrylic Dryfall
- C. Hollow Metal Doors and Frames – Semi-Gloss, Low-Odor/ Low VOC:
1. Primer: 1 coat S-W Pro Industrial Pro-Cryl Primer
 2. Finish: 2 coats S-W Pre-Catalyzed Epoxy Semi-Gloss
- D. Concrete Masonry Units at interior partitions - Low-Odor/Low VOC:
1. Primer: 1 coat S-W Loxon Block Surfacer.
 2. Finish: 2 coats S-W Pre-Catalyzed Epoxy Eg-Shel.

END OF SECTION

SECTION 09 96 00

HIGH PERFORMANCE COATINGS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. Section includes coating systems for water and wastewater facilities. Section includes surface preparation, shop coating and field coating of exterior and interior items and surfaces. Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatment specified in other Sections.
- B. Except as otherwise specified, coat all new substrates for which coating systems are listed in Part 2.
- C. Refer to Section 09 91 23 "Interior Painting" for paints used in the interior of the Administration building.

1.02 REFERENCES

- A. Abbreviations and Acronyms
- 1. Dry Film Thickness (DFT): Thickness of a coat of paint in fully cured state measured in mils (1/1000 inch).
- B. Definitions: ASTM D 16, unless otherwise specified.
- C. Reference Standards
 - 1. ASTM D16 Standard Terminology for Paint, Related Coatings, Materials and Applications
 - 2. ASTM D4263 Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
 - 3. ASTM F1869 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
 - 4. AWWA C652 Disinfection of Water-Storage Facilities.
 - 5. NSF/ANSI/CAN Standard 61 Drinking Water Systems Components
 - 6. NSF/ANSI/CAN Standard 600 Health Effects Evaluation and Criteria for Chemicals in Drinking Water
 - 7. ICRI Guideline No. 310.2 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

8. NAPF 500-03 Surface Preparation Standard For Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings
9. SSPC-PA 2 Measurement of Dry Coating Thickness with Magnetic Gages
10. SSPC-PA 11 Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating
11. SSPC-SP1 Solvent Cleaning
12. SSPC-SP 2 Hand Tool Cleaning
13. SSPC-SP 3 Power Tool Cleaning
14. SSPC-SP 5 White Metal Blast Cleaning
15. SSPC-SP 6 Commercial Blast Cleaning
16. SSPC-SP 10 Near-White Metal Blast Cleaning
17. SSPC-SP 11 Power Tool Cleaning to Bare Metal
18. SSPC-SP 12 Ultra-High-Pressure Water-Jetting
19. SSPC-SP 13 Surface Preparation of Concrete
20. SSPC-SP 16 Brush-off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.

1.03 SUBMITTALS

- A. Comply with the requirements specified in Section 01 33 00.
- B. Scheduling: Provide the paint submittals within 60 days of the Notice to Proceed
- C. Action Submittals/Informational Submittals
 1. Product Data: Submit manufacturer's product data for each coating, including generic description, complete technical data, surface preparation, storage requirements and application instructions.
 2. Color Samples: Submit manufacturer's color samples showing full range of standard colors.
 3. Submit manufacturer's certification that coatings comply with specified requirements and are suitable for intended application.

4. Applicator's Quality Assurance: Submit list of a minimum of three completed projects of similar size and complexity to this Work. Include for each project:
 - a. Project name and location.
 - b. Name of owner.
 - c. Name of contractor.
 - d. Name of engineer.
 - e. Name of coating manufacturer.
 - f. Approximate area of coatings applied.
 - g. Date of completion.

D. Maintenance Material Submittals

1. Extra Stock Materials: Furnish one gallon of each coating and color used.

1.04 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00
- B. Provide Regulatory Agency Sustainability Approvals for coating products.
- C. Qualifications
 1. Manufacturer
 - a. Specialize in manufacture of coatings with a minimum of 5 years of successful experience.
 - b. Demonstrate successful performance on comparable projects.
 - c. Single-Source Responsibility: Coatings and coating reducers shall be products of a single manufacturer.
 2. Applicator
 - a. Experienced in application of specified coatings for a minimum of 5 years on projects of similar size and complexity to this Work.
 - b. Applicator's Personnel: Employ persons trained for application of specified coatings.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging. Paint material containers which do not display manufacturer's product identification will not be acceptable. Container labels to clearly identify:
 - 1. Coating or material name.
 - 2. Manufacturer.
 - 3. Color name and number.
 - 4. Batch or lot number.
 - 5. Date of manufacture.
 - 6. Mixing and thinning instructions.
- B. Storage
 - 1. Store materials in a clean dry area and within temperature range shown on the manufacturer's written instructions.
 - 2. Keep containers sealed until ready for use.
 - 3. Do not use materials beyond manufacturer's shelf life limits.
- C. Handling: Protect materials during handling and application to prevent damage or contamination.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Tnemec, Inc.
- B. Sherwin Williams, Protective & Marine Coatings

2.02 COATING SYSTEMS, GENERAL

- A. The number of coats specified is the minimum required. If additional coats are required to achieve the specified dry film thickness or to provide complete coverage, provide additional coats at no additional cost to the Owner.
- B. Material Compatibility: Provide block fillers, primers, and finish coat materials that are compatible with one another and with the substrates indicated under conditions of service and application as recommended by manufacturer, based on testing and field experience.

- C. Material Quality: Provide manufacturer's best quality paint material of the various coating types specified that are factory-formulated and recommended by manufacturer for application indicated.
- D. Colors: As selected by OWNER from manufacturer's full range, and as scheduled in Part 3.

2.03 COATING SYSTEMS FOR FERROUS METALS

- A. Ferrous Metals, Interior, Non-Submerged: Includes steel roof joists and miscellaneous steel. Roof decking and galvanized steel such as structural framing is not to receive coatings. See Section 2.05 for steel piping coating systems.
 - 1. Surface Preparation and shop prime: SSPC-SP6 Commercial Blast. Roof joists shall be shop primed meeting SSPC-SP1 standards, clean and dry.
 - 2. Priming or Spot Prime as needed:
 - a. Tnemec Series 115 Uni-Bond DF @ 1.5-2.5 mils DFT
 - b. Sherwin Williams Pro Industrial Pro-Cryl Universal Primer @ 1.5-2.5 mils DFT
 - 3. Intermediate
 - a. Tnemec Series 115 Uni-Bond DF @ 3.0-4.0 mils DFT
 - b. Sherwin Williams Pro Industrial Acrylic Semi-Gloss @ 3.0-4.0 mils DFT
 - 4. Finish:
 - a. Tnemec Series 115 UniBond DF at 3.0-4.0 mils DFT
 - b. Sherwin Williams Pro Industrial Acrylic Semi-Gloss @ 3.0-4.0 mils DFT
 - 5. Total DFT: 7.5 - 10.5 mils
- B. Ferrous Metals, Interior or Exterior, Submerged or Intermittently Submerged in Water. Potable water submergence requires the coating system to be NSF 61/600 certification.
 - 1. Surface Preparation: SSPC-SP10 Near White Blast
 - 2. Shop Primer:
 - a. Tnemec Series 21 Epoxoline @ 3.0 – 5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 3.0-5.0 mils DFT

3. Field Preparation (as needed for spot repair): Mechanically abrade repair areas to de-gloss and profile the surface.
4. Field Spot Prime (as needed):
 - a. Tnemec Series Epoxoline @ 3.0-5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 3.0-5.0 mils DFT
5. Stripe Coat:
 - a. Tnemec Series 21 Epoxoline
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product
6. Intermediate:
 - a. Tnemec Series 21 Epoxoline @ 4.0 - 6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 4.0-6.0 mils DFT
7. Finish:
 - a. Tnemec Series 21 Epoxoline @ 4.0 - 6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 4.0 - 6.0 mils DFT
8. Total DFT: 11.0 – 17.0 mils

C. Ferrous Metals, Encased in Concrete and Cementitious Substances:

1. Surface Preparation: SSPC-SP6 Commercial Blast
2. Primer:
 - a. Tnemec Series V69 High-Build Epoxoline II @4.0 - 6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 4.0 -6.0 mils DFT
3. Finish:
 - a. Tnemec Series V69 High-Build Epoxoline II @ 4.0 - 6.0 DFT
 - b. Sherwin Williams Macropoxy 646 @4.0 -6.0 DFT
4. Total DFT: 8.0 - 12.0 mils

- D. Ferrous Metals, Exterior, Non-Submerged including structural steel:
1. Surface Preparation: SSPC-SP6 Commercial Blast
 2. Shop Primer:
 - a. Tnemec Series 90-97 Tneme-Zinc @ 2.5 - 3.5 mils DFT
 - b. Sherwin Williams Corothane I Galvapak @ 2.5 – 3.5 mils DFT
 3. Field Preparation: SSPC-SP6 Commercial Blast or SSPC-SP11 Power Tool Cleaning
 4. Field Touch-Up:
 - a. Tnemec Series 394 PerimePrime @ 2.5 - 3.5 mils DFT
 - b. Sherwin Williams Corothane I Galvapak @ 2.5 – 3.5 mils DFT
 5. Field Intermediate:
 - a. Tnemec Series V69 High-Build Epoxoline II @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 3.0 – 5.0 mils DFT
 6. Finish:
 - a. Tnemec Series 1095 Endura-Shield @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Acrolon 218HS @ 3.0 – 5.0 mils DFT
 7. Total DFT: 6.0 - 10.0 mils
- E. Ferrous Metals, Buried, Exterior, as needed.
1. Surface Preparation: SSPC-SP10 Near White Blast
 2. Shop Primer:
 - a. Tnemec Series 46H-413 Tneme-Tar @ 8.0 - 10.0 mils DFT
 - b. Sherwin Williams Hi-Mil Sher-Tar Epoxy @ 8.0 – 10.0 mils DFT
 3. Finish:
 - a. Tnemec Series 46H-413 Tneme-Tar @ 8.0 - 10.0 mils DFT
 - b. Sherwin Williams Hi-Mil Sher-Tar Epoxy @ 8.0 – 10.0 mils DFT
 4. Total DFT: 16.0 - 20.0 mils

2.04 COATING SYSTEMS FOR HOLLOW METAL WORK

A. Hollow Metal Work – Interior and Exterior:

1. Surface Preparation: SSPC-SP2/SP3 Hand and Power Tool Cleaning, feather all rough edges, remove loose rust, dirt, and other surface contaminants with sandpaper, scotch brite, etc.
2. Provide with 2-3.5 mils DFT factory-applied primer.
3. Field Preparation: SSPC-SP2/SP3 Hand and Power Tool Cleaning, feather all rough edges, remove loose rust, dirt, and other surface contaminants with sandpaper, scotch brite, etc.
4. Field Intermediate:
 - a. Tnemec Series V69 High-Build Epoxoline II @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 3.0 – 5.0 mils DFT
5. Finish:
 - a. Tnemec Series 1095 Endura-Shield @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Acrolon 218HS or Hi-Solids Polyurethane @ 3.0 – 5.0 mils DFT
6. Total DFT: 6.0 - 10.0 mils

2.05 COATING SYSTEMS FOR STEEL, DUCTILE IRON, AND CAST IRON PIPE

A. Outside-diameter surface coating for Steel, Ductile and Cast-Iron Pipe - Interior Non-Submerged:

1. Surface preparation:
 - a. Steel Pipe: SSPC-SP 6 Commercial Blast Cleaning
 - b. Ductile Iron Pipe: NAPF 500-03-04 Abrasive Blast Cleaning
 - c. Cast Iron Pipe NAPF 500-03-05 Abrasive Blast Cleaning
2. Shop Primer:
 - a. Tnemec Series N140 Pota Pox Plus or Series V69 High-Build Epoxoline II @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 3.0 – 5.0 DFT

3. Intermediate
 - a. Tnemec Series V69 High-Build Epoxoline II @ 4.0-6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 4.0 – 6.0 mils DFT
 4. Finish:
 - a. Tnemec Series V69 High-Build Epoxoline II @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 3.0 – 5.0 mils DFT
 5. Total DFT: 10.0 - 16.0 mils
- B. Outside diameter surface coating for Steel, Ductile and Cast-Iron Pipe. Exterior Non-Submerged:
1. Surface preparation:
 - a. Steel Pipe: SSPC-SP 6 Commercial Blast Cleaning
 - b. Ductile Iron Pipe: NAPF 500-03-04 Abrasive Blast Cleaning
 - c. Cast Iron Pipe NAPF 500-03-05 Abrasive Blast Cleaning
 2. Shop Primer:
 - a. Tnemec Series N140 Pota Pox Plus or Series V69 High-Build Epoxoline II @ 3.0 - 5.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 3.0 – 5.0 DFT
 3. Intermediate:
 - a. Tnemec Series V69 High-Build Epoxoline II @ 4.0 - 6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646 @ 4.0 – 6.0 DFT
 4. Finish:
 - a. Tnemec EnduraShield Series 1095 @ 3.0 - 5.0 DFT
 - b. Sherwin Williams Acrolon 218HS @ 3.0 – 5.0 DFT
 5. Total DFT: 10.0 - 16.0 mils
- C. Outside diameter surface coating for Steel, Ductile and Cast Iron Pipe, Interior or Exterior, Submerged or Intermittently Submerged in Potable Water. Potable water submergence requires the coating system to be NSF 61/600 certification.

1. Surface Preparation:
 - a. Steel Pipe: SSPC-SP10 Near-White Metal Blast Cleaning
 - b. Ductile Iron Pipe: NAPF 500-03-04 Abrasive Blast Cleaning
 - c. Cast Iron Pipe NAPF 500-03-05 Abrasive Blast Cleaning
2. Shop Primer:
 - a. Tnemec N140 Pota Pox Plus @ 3.0 – 4.0 DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 3.0 – 4.0 mils DFT
3. Field Preparation: Scarify the prime coat surface by brush-blasting with a fine abrasive before top-coating if it has been exposed to the exterior for 30 days or longer.
4. Stripe Coat:
 - a. Tnemec Series 21 Epoxyline
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product
5. Intermediate:
 - a. Tnemec Series 21 Epoxoline @ 4.0 - 6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 4.0 – 6.0 mils DFT
6. Finish:
 - a. Tnemec Series 21 Epoxoline @ 4.0 - 6.0 mils DFT
 - b. Sherwin Williams Macropoxy 646PW or equivalent NSF61 product @ 4.0 – 6.0 mils DFT
7. Total DFT: 11.0 – 16.0 mils

D. Outside diameter surface of Buried Steel, Ductile and Cast Iron Pipe:

1. Pipe surface shall receive surface preparation and bitumastic shop coating suitable for buried steel, ductile, or cast iron piping. Bitumastic coating shall be 16-20 mils DFT and be Tnemec series 46H-413 Tneme-Tar, Sherwin Williams Hi-Mil Sher-Tar Epoxy, or equivalent product. Additional field coatings are not required unless necessary for field-touch up application.

- E. Inside diameter lining of Steel and Ductile Iron Pipe, 10" and Greater. Products shall be NSF 61/600 certified.
1. Provide only where indicated on plans or piping schedules.
 2. Design basis is Tnemec. Equivalent NSF61 product(s) by Sherwin Williams are considered acceptable upon review.
 3. Surface Preparation
 - a. Steel Pipe: SSPC-SP10 Near White Blast with a minimum angular profile of 3.0.
 - b. Ductile Iron Pipe: NAPF 500-03-04 Abrasive Blast Cleaning for Ductile Iron Pipe
 4. Finish:
 - a. Tnemec Series 22 Epoxoline @ 30.0 - 40.0 mils DFT
 5. Total DFT: 30.0 – 40.0 mils
 6. Colors: 1255 Beige, 1218 Blue, or WH11 Off-White.
 7. Certification: Epoxy shall be sourced certified. Maximum thinner of 5% Thinner #2, recoat cure time and temperature shall be 16 hours at 75°F, and final cure time and temperature shall be 5 days at 75°F. Mix ratio shall be Part A to Part B of 1:1 by volume.
- F. Inside diameter lining of Steel and Ductile Iron Pipe, 6" and 8". Products shall be NSF 61/600 certified.
1. Provide only where indicated on plans or piping schedule.
 2. Design basis is Tnemec. Equivalent NSF61 product(s) by Sherwin Williams are considered acceptable upon review.
 3. Surface Preparation
 - a. Steel Pipe: SSPC-SP10 Near White Blast with a minimum angular profile of 1.5.
 - b. Ductile Iron Pipe: NAPF 500-03-04 Abrasive Blast Cleaning for Ductile Iron Pipe
 4. Shop Primer:
 - a. Tnemec Series 1220 @ 5.0-7.5 mils DFT

5. Finish:
 - a. Tnemec Series 1220 @ 5.0-7.5 mils DFT
6. Total DFT: 10.0 – 15.0 mils
7. Colors: White
8. Certification: Epoxy shall be sourced certified. Maximum thinner of 15% water. Recoat cure time and temperature shall be 6 hours at 75°F, and final cure time and temperature shall be 7 days at 75°F. Mix ratio shall be Part A to Part B of 2:1 by volume. Series 44-700 Accelerator may be added up to 1 fl. oz./gal.

2.06 COATING SYSTEMS FOR NON-FERROUS METALS

- A. Galvanized, Aluminum and other Non-Ferrous Metals such as stainless steel, copper, and brass shall not receive coatings.

2.07 COATING SYSTEMS FOR CONCRETE AND CONCRETE BLOCK

- A. Concrete Walls and Ceilings, Cast-in-Place or Precast, Non-Submerged (Interior):
 1. Provide only where indicated on the coating schedules.
 2. Surface Preparation: ICRI, International Concrete Repair Institute Guideline No. 310.2 and SSPC-SP13.
 3. Primer (Sprayed and backrolled):
 - a. Tnemec Series V69 High-Build Epoxoline II with coverage of 100 to 150 square feet per gallon.
 - b. Sherwin Williams Macropoxy 646 with coverage of 100 to 150 square feet per gallon.
 4. Finish:
 - a. Tnemec Series V69 High-Build Epoxoline II with coverage of 100 to 150 square feet per gallon.
 - b. Sherwin Williams Macropoxy 646 with coverage of 100 to 150 square feet per gallon.
 5. Total DFT: Approximately 8.0 – 12.0 mils
- B. Concrete Block Walls, Interior:
 1. Provide only where indicated on the coating schedules.

2. Surface Preparation: Allow mortar to cure no less than 14 days, remove all spatter and nibs. Level protrusions. Clean and dry.
 3. Primer:
 - a. Tnemec 130 - Envirofill @ coverage of 60 to 115 square feet per gallon.
 - b. Sherwin Williams Cement-Plex 875 @ coverage of 60 to 115 square feet per gallon.
 4. Intermediate:
 - a. Tnemec Series V69 High-Build Epoxoline II @ coverage of 100 to 125 square feet per gallon.
 - b. Sherwin Williams Macropoxy 646 @ coverage of 100 to 125 square feet per gallon.
 5. Finish:
 - a. Tnemec Series V69 High-Build Epoxoline II @ coverage of 100 to 125 square feet per gallon.
 - b. Sherwin Williams Macropoxy 646 @ coverage of 100 to 125 square feet per gallon.
 6. Total DFT: Approximately 18.0 - 24.0 mils
- C. Concrete, precast, stucco and block walls - Exterior - Coated:
1. Provide only where indicated on the coating schedule.
 2. Surface Preparation: Prepare concrete surfaces in accordance with SSPC-SP13 Joint Surface Preparation Standards and ICRI Technical Guidelines. Pressure wash to remove all loose coating and contaminants. All surfaces must be clean and dry.
 3. Surfacer/Filler (as needed for large bugholes and voids in the concrete): Tnemec Series 218 MortarClad or Envirofill Series 130, or equivalent Sherwin Williams Product.
 4. Cracks: Fill hairline cracks less than 1/64" wide by brushing Tnemec Series 156 or equivalent Sherwin Williams product into them prior to application of primer coat.
 5. Primer:
 - a. Tnemec Series 156 Enviro-Crete at 4.0 – 8.0 mils DFT
 - b. Sherwin Williams Loxon Acrylic Primer @ 4.0 – 8.0 DFT

6. Finish:

- a. Tnemec Series 156 Enviro-Crete at 4.0 – 8.0 mils DFT
- b. Sherwin Williams UltraCrete WB Textured Coating @ 4.0 – 8.0 DFT

7. Total DFT: 8.0 - 16.0 mils

D. Concrete, precast, stucco and block walls - Exterior - Clear:

1. Surface Preparation: Allow to cure 14 days.

2. Finish:

- a. Tnemec Prima- A Pell H20. Coverage dependent on substrate. Apply per product data sheet.
- b. Sherwin-Williams LOXON 7% Siloxane Water Repellant. Coverage dependent on substrate. Apply per product data sheet.

E. Concrete Walls and Other Concrete Surfaces (buried and below-grade):

1. Surface Preparation: ICRI, International Concrete Repair Institute Guideline No. 03732

2. Finish (2 coats):

- a. Tnemec 46-413 HB Tnemec-Tar @ 8.0 - 12.0 DFT each coat
- b. Sherwin Williams Hi-Mil Sher Tar Epoxy @ 8.0 – 12.0 DFT

3. Total DFT: 16.0 - 24.0 mils

F. Concrete Floor Sealant:

1. Surface Preparation: Per sealer manufacturer recommendations.

2. Finish Coat: Ashford Formula per product installation recommendations or equivalent sealant system.

2.08 COATING SYSTEMS FOR PVC

- A. PVC piping shall not receive a coating system. Provide decal labels for appropriate labeling of process piping applications (process water designation, chemicals, etc.).

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas where and conditions under which coating systems are to be applied. Notify Engineer of areas or conditions not acceptable. Do not begin surface preparation or application until unacceptable areas or conditions have been corrected.

3.02 PREPARATION

- A. Protection of In-place Conditions: Protect areas surrounding surfaces to be coated and surfaces not scheduled to be coated from damage during surface preparation and application of coatings.
- B. Surface Preparation: Prepare surfaces in accordance with this paragraph and the requirements listed in Part 2.

1. General

- a. Dislodge dirt, rust, plaster nibs, mortar spatter and other dry material by scraping or brushing. Remove dust and loose material by brushing, sweeping, vacuuming or blowing with compressed air.
- b. Remove oil, wax and grease by scraping off heavy deposits and cleaning with mineral spirits or a hot trisodium phosphate solution followed by a water rinse.
- c. Verify surfaces to be coated are dry, clean and free of dust, dirt, oil, wax, grease or other contaminants.

2. Non-Submerged Concrete, Masonry and Cement Stucco

- a. Allow new concrete and masonry to cure 28 days. Test for moisture in accordance with ASTM D 4263 and, if necessary, F 1869.
- b. Scrape and grind fins and protrusions flush with surface.
- c. Patch holes and cracks flush with surface.
- d. Rake mortar joints clean.

3. Non-Ferrous Metal: SSPC-SP1 to remove all contaminants or detergent wash/rinse with "Add H2O" Hyperconcentrate.

4. Lightly abrade or brush blast submerged steel shop-primed with epoxy.

5. Galvanized Metal: Remove contaminants by SSPC-SP1 Solvent Cleaning. Detergent clean with Oakite 747LTS. Abrade all galvanized metal in accordance with SSPC-SP16 Brush-off Blast Cleaning of Nonferrous Metals

6. Concrete Floors and Submerged Concrete: Prepare in accordance with ICRI, International Concrete Repair Institute Guideline No. 03732 and SSPC-SP13 Surface Preparation of Concrete using the appropriate degree of preparation for the intended surface.
7. Cast-in-Place and Precast Concrete to Receive Epoxy Finishes: Prepare in accordance with ICRI, International Concrete Repair Institute Guideline No. 03732 and SSPC-SP13 Surface Preparation of Concrete using the appropriate degree of preparation for the intended surface

3.03 APPLICATION

A. Weather

1. Air and Surface Temperatures: Prepare surfaces and apply and cure coatings within air and surface temperature range in accordance with manufacturer's written instructions.
2. Surface Temperature: Minimum of 5 degrees F (3 degrees C) above dew point.
3. Relative Humidity: Prepare surfaces and apply and cure coatings within relative humidity range in accordance with manufacturer's instructions.
4. Precipitation: Do not prepare surfaces or apply coatings in rain, snow, fog, or mist.

B. Ventilation: Provide ventilation during coating evaporation stage in confined or enclosed areas in accordance with AWWA D102.

C. Dust and Contaminants

1. Schedule coating work to avoid excessive dust and airborne contaminants.
2. Protect work areas from excessive dust and airborne contaminants during coating application and curing.

D. Protect all surfaces not to be coated

E. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels, unless specifically noted otherwise.

F. Apply coatings in accordance with manufacturer's instructions.

1. For porous masonry surfaces and concrete, apply first coat to completely fill voids and surface irregularities and to eliminate all pinholes.
2. Allow each coat to dry thoroughly before recoating. Follow manufacturer's recommended recoat time.

- G. Mix and thin coatings, including multi-component materials, in accordance with manufacturer's instructions.
- H. Keep containers closed when not in use to avoid contamination.
- I. Do not use mixed coatings beyond pot life limits.
- J. Use application equipment, tools, pressure settings, and techniques in accordance with manufacturer's instructions.
- K. Uniformly apply coatings at spreading rate required to achieve specified DFT.
- L. Apply coatings to be free of film characteristics or defects that would adversely affect performance or appearance of coating systems.
- M. Stripe-paint with brush critical locations on steel such as welds, corners, and edges using specified primer.
- N. Immediately remove coatings that fall on surrounding areas and surfaces not scheduled to be coated.
- O. Protect surfaces of coating systems from damage during construction.

3.04 REPAIR

- A. Materials and Surfaces Not Scheduled to Be Coated: Repair or replace damaged materials and surfaces.
- B. Damaged Coatings: Touch up or repair damaged coatings. Touch-up of minor damage will be acceptable where result is not visibly different from adjacent surfaces. Recoat entire surface where touch-up result is visibly different, either in sheen, texture, or color.
- C. Coating Defects: Repair in accordance with manufacturer's instructions coatings that exhibit film characteristics or defects that would adversely affect performance or appearance of coating systems.

3.05 CLEANING

- A. Remove temporary coverings and protection of surrounding areas and surfaces.
- B. Remove paint spatters from glass, plumbing fixtures, and adjoining surfaces.
- C. Remove debris from job site and leave storage areas clean.

3.06 SCHEDULES

- A. Pipe Color-Coding Schedule

Process flow (P&ID Abbreviation)	Pipe color	Lettering color	Background color
PROCESS FLOWS			
Raw Water (RW)	Olive green	Blue	White
UF Feed (UFI)	Olive green	Green	White
Strainer Backwash Waste (BWW)	Light Brown	White	Black
UF Filtrate (UFF)	Aqua	Blue	White
Ozonated Water (OZW)	Aqua	Blue	White
UF Backwash Waste (BWW)	Light brown	Black	White
UF Backwash Supply (BWS)	Dark Blue	Blue	White
All UF Air Purge Lines (PRG)	No coating – label only	Black	White
All UF CIP Lines (CSR)	No coating – label only	Red	White
Interior Tank Vents	Yellow	None	None
Backwash Recycle (BWR)	Olive green	White	Black
CIP Waste (Tank Outlet Piping) (DR)	Red	White	Black
Backwash Sludge (SLG)	Dark Brown	White	Black
Finished water (FW)	Dark blue	Blue	White
Clearwell Vents	Dark blue	None	None
OZONE SYSTEM		Orange	White
Liquid / gaseous oxygen	No coating – label only	Orange	White
Ozone solution	No coating – label only	Orange	White
Cooling water piping	No coating – label only	White	Black
Off-gas / destruct piping	No coating – label only	White	Black
Sample Piping	No coating – label only	Black	White
Low Pressure Air	Light green	White	Black
High Pressure Air	-	White	Black
CHLORINE GAS SYSTEM			
Rigid gas piping	Yellow	Black	White
Gas solution piping	No coating – label only	Black	Yellow
Scrubber Inlet and Outlet Piping (CLG, TEA)	No coating – label only	Black	Yellow
Chlorine Motive Water (UFF)	No coating – label only	Blue	White
OTHER CHEMICAL FEED			
Sodium bisulfite	No coating – label only	Brown	Light Yellow
Aluminum Chlorohydrate	No coating – label only	Black	Orange
Citric Acid	No coating – label only	Red	White
Sodium Hypochlorite	No coating – label only	Black	Yellow
Motive Water Supply	No coating – label only	Blue	White
MISCELLANEOUS PIPING			

Process flow (P&ID Abbreviation)	Pipe color	Lettering color	Background color
High Pressure Air (HPA)	No coating – label only	Green	White
Natural Gas	Red	Black	White
Local Sample Lines / Taps	Match Connecting Piping	-	-
Sample Lines Routed to Lab	No coating – label only	Match Process	Match Process

END OF SECTION

SECTION 09 96 73

COATING SYSTEMS FOR CHEMICAL FEED AREAS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. Section includes coating systems for secondary containment of liquid chemical feed storage areas in water treatment facilities, including concrete chemical containment trenches, sumps, and containment walls.

1.02 REFERENCES

- A. This Section contains references to the governing standards and documents listed below. They are a part of this Section as specified and modified; the current version shall apply unless otherwise noted. In case of conflict between the requirements of this section and those of the listed documents, the more stringent of the requirements shall prevail.
- B. American Concrete Institute, (ACI)
 - 1. ACI 301-10 – Specifications for Structural Concrete
 - 2. ACI 308 – Guide to Curing Concrete
- C. ASTM International (ASTM)
 - 1. ASTM C307 – Standard Test method for Tensile Strength of Chemical Resistant Mortars, Grouts, and Monolithic Surfacing.
 - 2. ASTM C413 – Standard Test Method for Absorption of Chemical Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - 3. ASTM C496 – Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
 - 4. ASTM C531 – Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - 5. ASTM C579 – Standard Test Methods for Compressive Strength of Chemical Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - 6. ASTM C580 – Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.

7. ASTM C596 – Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
8. ASTM C868 – Standard Test Method for Chemical Resistance of Protective Linings
9. ASTM C1583/1583M – Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
10. ASTM D638 – Standard Test Method for Tensile Properties of Plastics
11. ASTM D695 – Standard Test Method for Compressive Properties of Rigid Plastics
12. ASTM D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
13. ASTM D1653 – Standard Test Methods for Water Vapor Transmission of Organic Coating Films.
14. ASTM D2370 – Standard Test Method for Tensile Properties of Organic Coatings
15. ASTM D2794 – Standard Test Method for Resistance of Organic Linings to the Effects of Rapid Deformation (Impact).
16. ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
17. ASTM D4414 – Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
18. ASTM D6944 – Standard Practice for Determining the Resistance of Cured Coatings to Thermal Cycling
19. ASTM D7234 – Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
20. ASTM D7682 – Standard Test Method for Replication and Measurement of Concrete Surface Profiles Using Replica Putty.
21. ASTM E96 – Standard Test Methods for Water Vapor Transmission of Materials
22. ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
23. ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes

D. SSPC: The Society for Protective Coatings

1. SSPC-SP13/NACE No. 6 – Surface Preparation of Concrete

1.03 DELIVERY AND STORAGE

- A. Material shall be delivered to project site in manufacturer's original unopened containers.
- B. Clearly identify manufacturer's brand name, contents, color, batch number, and any personal safety hazards associated with the use of or exposure to the materials on each package.
- C. Packages showing indications of damage that may affect the condition of contents are not acceptable.
- D. Materials shall be stored in accordance with the manufacturer's recommendations in enclosed structures and shall be protected from weather and adverse temperature conditions. Flammable materials shall be stored in accordance with state and local codes. Materials exceeding storage life as defined by the manufacturer shall be removed promptly from the site. Store materials only in area or areas designated by the Engineer solely for this purpose.
- E. Store in original packaging under protective cover and protect from damage
- F. Stack containers in accordance with manufacturer's recommendations.

1.04 ENVIRONMENTAL CONDITIONS

- A. Surface and surrounding air temperatures must exceed 55 deg F but must be less than 90 deg F with materials at not less than 70 deg F during application. Do not apply if the relative humidity is more than 90% or the surface temperature is less than 5% above the dew point of the air in the working area.

1.05 QUALIFICATIONS OF APPLICATOR

- A. Installation shall be performed by an applicator having satisfactory experience in the application of these or similar materials or with on-site consultation by a qualified field service representative from the manufacturer.

1.06 SUBMITTALS

- A. Comply with Division 1 Requirements.
- B. Product Data Sheets: Copies of current technical data for each component specified and applied as outlined in this Section.
- C. Safety Data Sheets: Copies of current Safety Data Sheets (SDS) for any materials brought on-site, including clean-up solvents, repair or resurfacing mortars and lining materials.
- D. Installation Instructions: Manufacturer's written installation instructions for the materials specified in this Section.

- E. Owner, contractor, and manufacturer shall review and mutually agree upon color, grade, and final texture of coating system before starting installation. The acceptance of a sample will constitute the job standard by which installation will proceed.

1.07 WARRANTY

- A. The manufacturer shall warranty its products as free from material defects for a minimum period of three (3) years. Provide associated Warranty Certificate.
- B. The contractor shall warranty the installed protective lining system free from workmanship defects for a minimum period of three (3) years.

PART 2 - PRODUCTS

2.01 COMPATIBILITY

- A. Coatings shall be applied to the following containment areas. Manufacturer shall verify their proposed systems are compatible with the chemicals.
 - 1. Aluminum chlorohydrate coagulant, 35 to 40% concentration.
 - 2. Sodium Hypochlorite, 12 to 15% concentration
 - 3. Citric Acid, 50% concentration
 - 4. Sodium Bisulfite, 38% concentration

2.02 COATING PRODUCTS (OPTION #1)

- A. Basis of Design: Tnemec
 - 1. Surfacer / Filler as needed:
 - a. Tnemec Series 215 Surfacing Epoxy or Series 218 MortarClad
 - 2. Penetrating Epoxy Primer
 - a. Series 201 Epoxoprime
 - 3. Aggregate Filled Novolac Epoxy Basecoat and Saturant Coat
 - a. Series 239SC ChemBloc
 - 4. Fiberglass Reinforcement Mat
 - a. Series 211-215 Reinforcing Mat, ¾ ounce
 - 5. Novolac Epoxy Topcoat

- a. Series 282 Tnemec-Glaze
 - B. Coatings shall be applied in thicknesses as recommended by the Manufacturer or manufacturer data sheet.
- 2.03 MATERIALS (OPTION #2)
- A. Basis of Design: Dudick Inc.
 - 1. Primer:
 - a. Dudick Primer 67 high solids epoxy
 - 2. Resurfacer:
 - a. Dudick Scratch Coat 300 epoxy
 - 3. Reinforced Coating:
 - a. Protecto-Flex 100XT, Fiberglass mat reinforced with 100 mil crack protection guarantee.
 - 4. Coatings shall be applied in thicknesses as recommended by the Manufacturer or manufacturer data sheet.

PART 3 - EXECUTION

3.01 GENERAL

- A. The Applicator shall provide, erect, and maintain required hoists, scaffolding, staging, and planking, and perform access-related hoisting work required to complete the Work of this Section as specified.
- B. The Applicator shall cover or otherwise protect finish work or other surfaces not being coated within the scope of this Section. The Applicator shall erect and maintain protective tarps, enclosures and/or masking to contain debris, including dust or other airborne particles from surface preparation or application activities. This may include the use of dust or debris collection apparatus as required at no additional cost to Owner.

3.02 EXAMINATION

- A. The Applicator shall examine the areas and conditions under which the protective coating Work is to be performed in accordance with NACE SP0892 and SSPC-SP13/NACE No. 6, and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work.
- B. All concrete should be cured using the procedures described in ACI 308, allowing a minimum of 28 days at 75F.

- C. The Applicator shall confirm the presence of a vapor barrier or positive side waterproofing on the exterior of the concrete structure.
- D. Commencement of the Work of this Section shall indicate that the substrate and other conditions of installation are acceptable to the Contractor and his The Applicator, and will produce a finished product meeting the requirements of the Specifications. All defects resulting from accepted conditions shall be corrected by Applicator at his own expense

3.03 PREPARATION

- A. Concrete surfaces to receive protective coating shall be cast with a Smooth Form Finish in accordance with ACI 301. Surfaces shall not be rubbed, sacked, troweled, or otherwise finished in any manner that will obscure or cover the parent concrete surface with materials other than materials as specified in this Section.
- B. All surfaces must be clean, dry, and free of oil, grease, and other contaminants, prior to preparation in accordance with NACE No. 6/SSPC-SP13. Concrete surfaces must be sound and capable of supporting the protective coating system.
- C. Prepare concrete surfaces in accordance with NACE No. 6/SSPC-SP13 Joint Surface Preparation Standards and ICRI Technical Guidelines. Abrasive blast, shot-blast or mechanically abrade concrete surfaces to remove laitance, curing compounds, hardeners, sealers, existing coatings, and other contaminants and to provide an ICRI-CSP 5 surface profile.
- D. Level or grind concrete substrates to produce a uniform and smooth surface, including removal of sharp edges, ridges, form fins, and other concrete protrusions.
- E. Contractor shall follow any additional manufacturer recommendations for surface preparation.

3.04 APPLICATION

- A. Protective coating systems shall be installed when ambient air and surface temperature is above 55°F. The substrate temperature shall be at least 5°F above the dew point. Condition the material between 70-90°F for 48 hours prior to use. Application when temperatures outside of this range will require written instruction from the Manufacturer and approval of the Engineer.
- B. Application in direct sunlight and/or with rising surface temperatures is not allowed, as this may result in blistering of the materials due to expansion of entrapped air or moisture in the concrete. In such cases, it will be necessary to postpone the application until later in the day when the temperature of the substrate is falling. Concrete surfaces that have been in direct sunlight should be shaded for at least 24 hours prior to application. Consult the Manufacturer for application schedule guidelines specific to temperature conditions and possible sealer application recommendations to reduce outgassing.

- C. Large voids, cracks, and other surface defects shall be filled or patched utilizing mortar or grout products approved by the Coating System manufacturer as needed prior to the installation of the containment lining system.
- D. Cant cove bases shall be installed using a mixed trowelable version of lining system in accordance with the Manufacturer's written instructions and as indicated on the Standard Secondary Containment Lining Details
- E. Areas not to receive containment lining shall be masked or otherwise protected to prevent these surfaces from being coated.
- F. Application (Materials Option #1)
 - 1. Epoxy primer: Apply Series 201 Epoxoprime in accordance with Manufacturer's written instructions as outlined in the product data sheet. To horizontal and vertical surfaces, roller-apply penetrating primer of Series 201 Epoxoprime at 6.0–8.0 mils DFT.
 - 2. Aggregate Filled Novolac Epoxy Basecoat: Apply Series 239SC Chembloc in accordance with Manufacturer's written instructions as outlined in the product data sheet. To horizontal and vertical surfaces, trowel apply mortar base coat of Series 239SC ChemBloc at 60.0–80.0 mils DFT.
 - 3. Fiberglass Reinforcing Mat: Embed Series 211-215 ¾ ounce fiberglass reinforcing mat into the basecoat while still wet and smooth with ribbed roller to remove any voids or wrinkles.
 - 4. Novolac Epoxy Saturant Coat: Apply Series 239SC ChemBloc Resin in accordance with Manufacturer's written instructions as outlined in the product data sheet. Saturate top of fiberglass mat completely with Series 239SC ChemBloc resin at 8.0–12.0 mils until glass attains a translucent, even appearance. Once cured, sand to remove any imperfections or fiberglass fibers that may be sticking up through the cured film. Grind if required to remove.
 - 5. Novolac Epoxy Topcoat: Apply Series 282 Tnemec-Glaze in accordance with Manufacturer's written instructions as outlined in the product data sheet. To horizontal and vertical surfaces, roller apply topcoat of Series 282 Tnemec-Glaze at 6.0–8.0 mils DFT.
- G. Installation (Materials Option #2)
 - 1. Priming: Dudick Inc Primer 67 shall be mechanically mixed and applied in accordance with manufacturer's printed instructions and applied uniformly at a film thickness of no less than 5.0 dry mils DFT.
 - 2. Resurfacing: Mechanical preparation removes laitance, exposing honeycombs or voids beneath the surface which must be filled with Dudick Inc Scratch-Coat 300, thickness as needed for complete resurfacing.

3. Fiber Reinforced Coating: Protecto-Flex 100XT shall be an epoxy lining consisting of 1/16" trowel applied basecoat, one layer of fiberglass mat reinforcement, and a flake filled epoxy topcoat of no less than 20 mils DFT.
4. Joints: Active expansion, construction and control joints are to be honored unless determined otherwise by the owner or project engineer. Joints and epoxy floor terminations are to be keyed and shall be sawed through the Coating system and filled with an appropriate Polysulphide flexible Dudick Caulk 149 sealant.

3.05 FIELD QUALITY CONTROL, INSPECTION AND TESTING

- A. The Applicator shall perform the quality control procedures listed below in conjunction with the requirements of this Section.
- B. Inspect materials upon receipt to ensure that the materials are supplied by the approved Manufacturer.
- C. Surface Profile: Inspect and record substrate profile (anchor pattern). Surfaces shall be profiled equal to the CSP 5 amplitude as recommended by the coating manufacturer in accordance with ICRI Guideline 310.2 and SSPC-SP13/NACE No. 6.
 1. Compare the substrate profile once every 50 square feet with the Concrete Surface Profile (CSP) comparators in accordance with ICRI Guideline No. 310.2.
 2. Perform replication of the concrete surface profile every 500 square feet using replica putty in accordance with ASTM D7682. Submit replications to the Engineer as part of the Jobsite Reports.
- D. Surface Cleanliness: Prepared concrete surfaces shall be inspected for surface cleanliness after cleaning and drying, prior to resurfacing or coating application.
- E. Concrete Moisture Testing: After surface preparation verify concrete dryness in accordance with ICRI Guidelines 310.2 and SSPC-SP13/NACE No. 6 with one or more of the following test methods.
 1. ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride. Moisture vapor transmission not to exceed three pounds per 1,000 square feet in a 24-hour period.
 2. ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probe. Relative humidity not to exceed 80 percent.
 3. ASTM D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method. No moisture present.
 4. Consult manufacturer regarding questions and or recommendations in reference to moisture problems or questions.

- F. Surface pH Testing – Existing Concrete: After surface preparation test the pH of cement particles collected from the concrete substrate. The particles shall be measured using pH indicating paper or pH meter. The pH testing is to be performed once every 50 square feet for the first 500 square feet and then once every 500 square feet thereafter. Acceptable pH values shall be a minimum of 9.0 as measured using color indicating pH paper with readable color calibrations and a scale at whole numbers or pH meter.
- G. Measure and record ambient air temperature, relative humidity, and dew point temperature once every two hours of each work shift.
- H. Measure and record substrate temperature once every two hours using an infrared or other surface thermometer.
- I. Film Thickness:
 - 1. Wet-Film Thickness shall be taken every 100 square feet in accordance with ASTM D4414 or other agreed-upon method.
 - 2. The Dry-Film Thickness can be determined using a surface area calculation for material consumption.
- J. The Applicator is responsible for keeping the Engineer informed of progress so that Engineer may provide additional quality control at his discretion.
- K. Inspection by the Engineer or others does not absolve the applicator from his responsibilities for quality control inspection and testing as specified herein or as required by the Manufacturer's instructions.

3.06 MANUFACTURER'S FIELD SERVICES:

- A. The manufacturer's technical representative shall provide technical assistance and guidance for surface preparation and application of coating systems.

3.07 ACCEPTANCE CRITERIA

- A. Surfaces shall be prepared, applied, and tested in accordance with the specification and referenced standards herein.

3.08 PROTECTION AND CLEANING

- A. Protect the completed Work from traffic, physical abuse, immersion, and chemical exposure until the complete system has thoroughly cured for 24 hours.
- B. At the completion of the Work, Applicator shall remove materials and debris associated with the Work of this Section.

- C. Clean surfaces that are not designated to receive protective coating. Restore in a manner acceptable to Engineer.
- D. Protect the complete Work protected from damage until Final Acceptance. Protective coating damaged in any manner shall be repaired or replaced at the discretion of the Engineer, at no additional cost to Owner.

END OF SECTION

SECTION 10 14 19
EXTERIOR SIGNAGE

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Exterior Logo Sign
 - 2. Dimensional characters.

1.02 COORDINATION

- A. Signage anchor locations are shown on the Contract Drawings. Sleeves shall be provided through the exterior wall system by the signage suppliers for mounting of the sign.
- B. Sign design shall include tolerances in housing framing to accommodate mounting using the indicated sleeve locations.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include furnished specialties and accessories.
 - 2. Include data for paint, coatings, and other finish materials as required to show compliance with specified requirements.
- B. Shop Drawings:
 - 1. Include fabrication and installation details and attachments to other work.
 - 2. Show sign mounting heights, locations of supplementary supports to be provided by other installers, and accessories.
 - 3. Show message list, typestyles, graphic elements, and layout for each sign at least half size.
- C. Delegated Design Engineering Drawings: Sealed and signed by Professional Structural Engineer, licensed in the State where the project is located, responsible for preparation of engineering analysis who thereby certifies preparing or supervising preparation of data to comply with specified requirements and recognized engineering principles and practices. Engineering Drawings include, but are not limited to:

1. Plans, elevations, sections, and details for fabrication and installation of sign structures indicating sizes, dimensions, and profiles; arrangement and provisions for jointing, supporting, anchoring, and fastening.
 2. Include details showing relationship with, attachment to, and reception of related Work.
 - a. Indicate details of adjoining Work, even though not included in Work of this Section, to ensure coordination of Work and Work of other Sections.
 - b. Schedule and describe anchorage assemblies and their related components.
 - c. Show location of inserts for anchors and supports, which are to be attached to structure. Note that the attachment points (sleeve locations) are indicated on the Contract Drawings.
 - d. Reference Drawing detail numbers where applicable.
- D. Engineering Analysis: Sealed and signed by Professional Structural Engineer, licensed in the State where the project is located, who thereby certifies preparing or supervising preparation of data to comply with specified requirements and recognized engineering principles and practices.
- E. Samples for Initial Selection: For each type of sign assembly, exposed component, and exposed finish.
1. Include representative Samples of available typestyles and graphic symbols.
- F. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:
1. Dimensional Characters: Full-size Sample of each type of dimensional character.
 2. Full-size Samples, if approved, will be returned to Contractor for use in the Project.
- G. Product Schedule: Use same designations indicated on Drawings or specified.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Manufacturer, Installer, and engineer.
- B. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For signs to include in maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Firm regularly engaged in manufacture of exterior signage essentially identical to products specified for this Project that have been in satisfactory service for minimum of two years.
 - 1. Contractor must demonstrate previous experience with Branding and Wayfinding signage programs for Commercial clients.
 - 2. Contractor to provide a minimum of two analogous examples of previous Commercial projects, illustrating a case study which includes pictures and an outline of the program planning, implementation and completion phases.
 - 3. Contractor to provide examples of three Commercial programs successfully completed over the past 10 years.
 - 4. Contractor to provide three letters of reference from past Commercial projects.
 - 5. Contractor to develop a proposed project schedule for managing a location, and include key milestones and task responsibilities.
 - 6. Contractor to demonstrate the capability for online reporting, and for creating a project database with customer /client accessibility.
- B. Installer Qualifications: Manufacturer or an entity that employs installers and supervisors who are trained and approved by manufacturer.
- C. Welding Qualifications: Qualify procedures and personnel for both field and shop/production facility according to AWS D1.1/D1.1M, "Structural Welding Code – Steel" D1.2/D1.2M, "Structural Welding Code – Aluminum" D1.3, "Structural Welding Code - Sheet Steel" D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."
- D. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or product that are similar in material, design, and extent to those indicated for this Project.

1.07 FIELD CONDITIONS

- A. Field Measurements: Inspect existing conditions and verify dimensions related to fabrication and installation of exterior signage.

1.08 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Deterioration of finishes beyond normal weathering.
 - b. Separation or delamination of sheet materials and components.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, to design sign structure and anchorage of exterior sign type(s) as shown on Drawings according to structural performance requirements.
- B. Structural Performance: Signs and supporting elements shall withstand the effects of gravity and other loads within limits and under conditions indicated.
 1. Uniform Wind Load: As indicated on Drawings.
 2. Concentrated Horizontal Load: As indicated on Drawings.
 3. Other Design Load: As indicated on Drawings
 4. Uniform and concentrated loads need not be assumed to act concurrently.
- C. Thermal Movements: For exterior signage, allow for thermal movements from ambient and surface temperature changes.
 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.02 SIGN SYSTEMS

- A. Logo Sign: Provide logo sign as shown on Drawings and as approved by Owner.
- B. Cast Characters: Characters with uniform faces, sharp corners, and precisely formed lines and profiles, and as follows:
 1. Character Material: Cast aluminum.
 2. Character Height: As indicated on Drawings.
 3. Thickness: Manufacturer's standard for size of character.

4. Finishes:

- a. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard, in color as selected by Engineer from manufacturer's full range.

5. Mounting: As indicated on Drawings.

2.03 SIGN MATERIALS

- A. Aluminum Castings: ASTM B26/B26M, alloy and temper recommended by sign manufacturer for casting process used and for type of use and finish indicated.
- B. Aluminum Sheet and Plate: ASTM B209 (ASTM B209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
- C. Aluminum Extrusions: ASTM B221 (ASTM B221M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
- D. Paints and Coatings for Sheet Materials: Inks, dyes, and paints that are recommended by manufacturer for optimum adherence to surface and are UV and water resistant for colors and exposure indicated.

2.04 ACCESSORIES

- A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signs, noncorrosive and compatible with each material joined, and complying with the following:
 - 1. Use concealed fasteners and anchors unless indicated to be exposed.
 - 2. For exterior exposure, furnish nonferrous-metal or stainless steel devices unless otherwise indicated.
 - 3. Exposed Metal-Fastener Components, General:
 - a. Fabricated from same basic metal and finish of fastened metal unless otherwise indicated.
 - 4. Sign Mounting Fasteners:
 - a. Concealed Studs: Concealed (blind), threaded studs welded or brazed to back of sign material, screwed into back of sign assembly, or screwed into tapped lugs cast integrally into back of cast sign material, unless otherwise indicated.
 - b. Projecting Studs: Threaded studs with sleeve spacer, welded or brazed to back of sign material, screwed into back of sign assembly, or screwed into tapped lugs cast integrally into back of cast sign material, unless otherwise indicated.
 - c. Through Fasteners: Exposed metal fasteners matching sign finish, with type of head indicated, installed in predrilled holes.

2.05 FABRICATION

- A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
 - 1. Preassemble signs and assemblies in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
 - 2. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.
 - 3. Comply with AWS for recommended practices in welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed connections of flux, and dress exposed and contact surfaces.
 - 4. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
 - 5. Internally brace dimensional characters for stability, to meet structural performance loading without oil-canning or other surface deformation, and for securing fasteners.
 - 6. Provide rabbets, lugs, and tabs necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.
 - 7. Castings: Fabricate castings free of warp, cracks, blowholes, pits, scale, sand holes, and other defects that impair appearance or strength. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks before finishing.

2.06 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.07 ALUMINUM FINISHES

- A. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Verify that sign-support surfaces are within tolerances to accommodate signs without gaps or irregularities between backs of signs and support surfaces unless otherwise indicated.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF SIGNS

- A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
 - 1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.
 - 2. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.
 - 3. Corrosion Protection: Coat concealed surfaces of exterior aluminum in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

3.03 ADJUSTING AND CLEANING

- A. Remove and replace damaged or deformed characters and signs that do not comply with specified requirements. Replace characters with damaged or deteriorated finishes or components that cannot be successfully repaired by finish touchup or similar minor repair procedures.
- B. Remove temporary protective coverings and strippable films as signs are installed.
- C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions, and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by Owner.

END OF SECTION

SECTION 10 14 23

PANEL SIGNAGE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Panel signs.

1.02 COORDINATION

- ###### A.
- Furnish templates for placement of sign-anchorage devices embedded in permanent construction by other installers.

1.03 ACTION SUBMITTALS

A. Product Data:

1. Panel signs.

B. Shop Drawings: For panel signs.

1. Include fabrication and installation details and attachments to other work.
2. Show sign mounting heights, locations of supplementary supports to be provided by other installers, and accessories.
3. Show message list, typestyles, graphic elements, and layout for each sign at least half size.
4. Show locations of electrical service connections.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For each type of sign assembly, exposed component, and exposed finish.

1. Include representative Samples of available typestyles and graphic symbols.

D. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:

1. Panel Signs: Full-size Sample.

2. Full-size Samples, if approved, will be returned to Contractor for use in Project.

E. Product Schedule: For panel signs. Use same designations indicated on Drawings or specified.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance Data: For signs to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer of products.

1.07 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration of finishes beyond normal weathering.

b. Deterioration of embedded graphic image.

c. Separation or delamination of sheet materials and components.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Thermal Movements: For exterior signs or signs in unconditioned spaces, allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

B. Accessibility Standard: Comply with applicable provisions in ICC A117.1.

2.02 PANEL SIGNS

- A. Panel Sign: Sign with smooth, uniform surfaces; with message and characters having uniform faces, sharp corners, and precisely formed lines and profiles; and as follows:
 - 1. All materials shall be non-corrosive.
 - 2. Sign size, configuration, assembly, and mounting as shown on Drawings.
 - a. Confirm all signage language with Owner.
 - 3. Flatness Tolerance: Sign is to remain flat or uniformly curved under installed conditions as indicated on Drawings and within a tolerance of plus or minus 1/16 inch (1.5 mm) measured diagonally from corner to corner.

2.03 PANEL-SIGN MATERIALS

- A. Aluminum Sheet and Plate: ASTM B209 (ASTM B209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
- B. Aluminum Extrusions: ASTM B221 (ASTM B221M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
- C. Stainless Steel Sheet: ASTM A240/A240M or ASTM A666, Type 304, stretcher-leveled standard of flatness.
- D. Acrylic Sheet: ASTM D4802, category as standard with manufacturer for each sign, Type UVF (UV filtering).
- E. Fiberglass Sheet: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.
- F. Polycarbonate Sheet: ASTM C1349, Appendix X1, Type II (coated, mar-resistant, UV-stabilized polycarbonate), with coating on both sides.
- G. Paints and Coatings for Sheet Materials: Inks, dyes, and paints that are recommended by manufacturer for optimum adherence to surface and are UV and water resistant for colors and exposure indicated.

2.04 ACCESSORIES

- A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signs, noncorrosive and compatible with each material joined, and complying with the following unless otherwise indicated:
 - 1. Use concealed fasteners and anchors unless indicated to be exposed.
 - 2. Furnish nonferrous-metal or stainless steel devices unless otherwise indicated.

- B. Adhesive: As recommended by sign manufacturer.
- C. Two-Face Tape: Manufacturer's standard high-bond, foam-core tape, 0.045 inch (1.14 mm) thick, with adhesive on both sides.
- D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.05 FABRICATION

- A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
 - 1. Preassemble signs in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
 - 2. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.
 - 3. Comply with AWS for recommended practices in welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed connections of flux, and dress exposed and contact surfaces.
 - 4. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
 - 5. Internally brace signs for stability, to meet structural performance loading without oil-canning or other surface deformation, and for securing fasteners.
 - 6. Provide rabbets, lugs, and tabs necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.
- B. Brackets: Fabricate brackets, fittings, and hardware for bracket-mounted signs to suit sign construction and mounting conditions indicated. Modify manufacturer's standard brackets as required.

2.06 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

- C. Directional Finishes: Run grain with long dimension of each piece and perpendicular to long dimension of finished trim or border surface unless otherwise indicated.

2.07 ALUMINUM FINISHES

- A. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

2.08 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 - 2. Directional Satin Finish: No. 4.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Verify that sign-support surfaces are within tolerances to accommodate signs without gaps or irregularities between backs of signs and support surfaces unless otherwise indicated.
- C. Verify that anchorage devices embedded in permanent construction are correctly sized and located to accommodate signs.
- D. Verify that electrical service is correctly sized and located to accommodate signs.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
 - 1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.

2. Install signs so they do not protrude or obstruct according to the accessibility standard.
 3. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.
 4. Corrosion Protection: Coat concealed surfaces of exterior aluminum in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- B. Signs Mounted on Glass: Provide opaque sheet matching sign material and finish onto opposite side of glass to conceal back of sign and two-face tape.

3.03 ADJUSTING AND CLEANING

- A. Remove and replace damaged or deformed signs and signs that do not comply with specified requirements. Replace signs with damaged or deteriorated finishes or components that cannot be successfully repaired by finish touchup or similar minor repair procedures.
- B. Remove temporary protective coverings and strippable films as signs are installed.
- C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions, and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by Owner.

END OF SECTION

SECTION 10 28 00

TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Public-use washroom accessories.
 - 2. Custodial accessories.

1.02 COORDINATION

- A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.
- B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.03 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
 - 3. Include electrical characteristics.
- B. Samples: For each exposed product and for each finish specified, full size.
 - 1. Approved full-size Samples will be returned and may be used in the Work.

1.04 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For manufacturer's special warranties.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For accessories to include in maintenance manuals.

1.06 WARRANTY

- A. Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, visible silver spoilage defects.
 - 2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Design accessories and fasteners to comply with the following requirements:
 - 1. Grab Bars: Installed units are able to resist 250 lbf (1112 N) concentrated load applied in any direction and at any point.

2.02 PUBLIC-USE WASHROOM ACCESSORIES

- A. Source Limitations: Obtain each type of public-use washroom accessory from single source from single manufacturer.
- B. Toilet Tissue (Roll) Dispenser:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
 - 2. Description: Roll-in-reserve dispenser with hinged front secured with tumbler lockset.
 - 3. Mounting: Surface mounted.
 - 4. Operation: Noncontrol delivery with standard spindle.
 - 5. Capacity: Designed for 4-1/2- or 5-inch- (114- or 127-mm-) diameter tissue rolls.
 - 6. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

C. Automatic Paper Towel (Roll) Dispenser:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Description: Automatic motion-sensing mechanism with user-adjustable delay and paper towel length; battery powered.
3. Mounting: Surface mounted.
4. Minimum Capacity: 8-inch- (203-mm-) wide, 800-foot- (244-m-) long roll.
5. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
6. Lockset: Tumbler type.

D. Soap Dispenser:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Description: Designed for manual operation and dispensing soap in liquid or lotion form.
3. Mounting: Vertically oriented, surface mounted.
4. Capacity: 40-fl.oz. (1.2-L).
5. Exposed Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

6. Lockset: Tumbler type.
7. Refill Indicator: Window type.

E. Grab Bar:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Mounting: Flanges with concealed fasteners.
3. Material: Stainless steel, 0.05 inch (1.3 mm) thick.
 - a. Finish: Smooth, ASTM A480/A480M No. 4 finish (satin).
4. OD: 1-1/2 inches (38 mm).
5. Configuration and Length: As indicated on Drawings.

F. Seat-Cover Dispenser:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Mounting: Surface mounted.
3. Minimum Capacity: 250 seat covers.
4. Exposed Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

5. Lockset: Tumbler type.

G. Mirror Unit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Frame: Stainless steel angle, 0.05 inch (1.3 mm) thick.
 - a. Corners: Welded and ground smooth.
3. Size: As indicated on Drawings.
4. Hangers: Manufacturer's standard rigid, tamper and theft resistant.

H. Hook:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Description: Double-prong unit.
3. Mounting: Concealed.
4. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

2.03 CUSTODIAL ACCESSORIES

- A. Source Limitations: Obtain custodial accessories from single source from single manufacturer.

B. Custodial Mop and Broom Holder:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - d. Brey-Krause Manufacturing Co.
2. Description: Unit with shelf, hooks, holders, and rod suspended beneath shelf.
3. Length: 36 inches (914 mm).
4. Hooks: Four.
5. Mop/Broom Holders: Three, spring-loaded, rubber hat, cam type.
6. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
 - a. Shelf: Not less than nominal 0.05-inch- (1.3-mm-) thick stainless steel.
 - b. Rod: Approximately 1/4-inch- (6-mm-) diameter stainless steel.

2.04 MATERIALS

- A. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.031-inch- (0.8-mm-) minimum nominal thickness unless otherwise indicated.
- B. Fasteners: Screws, bolts, and other devices of same material as accessory unit, unless otherwise recommended by manufacturer or specified in this Section, and tamper and theft resistant where exposed, and of stainless or galvanized steel where concealed.
- C. Mirrors: ASTM C1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.05 FABRICATION

- A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.
- B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
 - 1. Remove temporary labels and protective coatings.
 - 2. Adhered installations are not allowed.
- B. Grab Bars: Install to comply with specified structural-performance requirements.

3.02 ADJUSTING AND CLEANING

- A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.
- B. Clean and polish exposed surfaces in accordance with manufacturer's written instructions.

END OF SECTION

SECTION 10 41 16

EMERGENCY KEY CABINETS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Emergency key cabinets.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product. Show cabinet type, and trim style. Include roughing-in dimensions and details showing recessed-mounting method and relationships of box and trim to surrounding construction.
- B. Samples: For each type of exposed finish required.

1.03 COORDINATION

- A. Coordinate size of emergency key cabinets to ensure that type and capacity of stored keys indicated are accommodated.
- B. Coordinate sizes and locations of emergency key cabinets with wall depths.

PART 2 - PRODUCTS

2.01 EMERGENCY KEY CABINET

A. Exterior Emergency Key Cabinets:

1. Basis-of-Design: Subject to compliance with the requirements, provide Rapid Entry System Hinged Door Series 3200 Knox-Box as manufactured by Knox Co., Phoenix, AZ, or comparable product by one of the following:
 - a. Manufacturer as approved by Engineer.
2. Locations: As shown on Drawings.
3. Exterior emergency key cabinets shall be approximately 4"H x 5" W x 3-3/4" D capable of holding up to 10 keys and access cards in interior compartment, fabricated of heavy-duty, drill-resistant, 1/4-inch solid steel housing, 100% welded construction.

4. High security UL listed double-action rotating tumblers and hardened steel pins accessed by a biased cut key. Lock shall have 1/8" thick stainless steel dust cover with tamper seal mounting capability.
5. Provide 4 keys to each cabinet master-keyed to the local Fire Department keying system.
6. Dead bar protected stainless steel hinge.
7. Door: 1/2-inch thick steel door with three-bolt latch and weather resistant door gasket.
8. Hinged door shall allow single hand operation.
9. Connect emergency key cabinet to building's alarm system

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine walls for suitable anchorage where cabinets will be installed.
- B. Examine roughing-in for alarm systems to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Prepare substrate for emergency key cabinets as required by type and size of cabinet.
- B. Coordinate alarm system connections with Division 28 Sections.

3.03 INSTALLATION

- A. General: Install emergency key cabinets in locations and at mounting heights indicated or, if not indicated, at heights acceptable to authorities having jurisdiction.
- B. Emergency Key Cabinets: Fasten cabinets to structure, square and plumb.

3.04 ADJUSTING AND CLEANING

- A. Remove temporary protective coverings and strippable films, if any, as emergency key cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.
- B. On completion of emergency key cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.

- C. Touch up marred finishes, or replace emergency key cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by emergency key cabinet manufacturer.
- D. Replace emergency key cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 10 44 13
FIRE PROTECTION CABINETS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Fire-protection cabinets for the following:
 - a. Portable fire extinguisher.

B. Related Requirements:

1. Section 10 44 16 "Fire Extinguishers" for portable, hand-carried fire extinguishers accommodated by fire-protection cabinets

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Show door hardware, cabinet type, trim style, and panel style. Include roughing-in dimensions and details showing semirecessed-, or surface-mounting method and relationships of box and trim to surrounding construction.

B. Shop Drawings: For fire-protection cabinets.

1. Include plans, elevations, sections, details, and attachments to other work.

1.03 CLOSEOUT SUBMITTALS

A. Maintenance Data: For fire-protection cabinets to include in maintenance manuals.

1.04 COORDINATION

- A. Coordinate size of fire-protection cabinets to ensure that type and capacity of fire extinguishers indicated are accommodated.
- B. Coordinate sizes and locations of fire-protection cabinets with wall depths.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain fire-protection cabinets, accessories, and fire extinguishers from single source from single manufacturer.

2.02 FIRE-PROTECTION CABINET

- A. Cabinet Type: Suitable for fire extinguisher.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Guardian Fire Equipment, Inc.
 - b. J. L. Industries, Inc.; Activar Construction Products Group, Inc.
 - c. Larsen's Manufacturing Company.
 - d. Nystrom, Inc.
 - e. Potter Roemer LLC; a Division of Morris Group International.
 - f. Strike First Corporation of America.
- B. Cabinet Construction: Nonrated.
- C. Cabinet Material: Stainless steel sheet.
- D. Semirecessed Cabinet: One-piece combination trim and perimeter door frame overlapping surrounding wall surface, with exposed trim face and wall return at outer edge (backbend).
 - 1. Square-Edge Trim: 1-1/4- to 1-1/2-inch (32- to 38-mm) backbend depth.
- E. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall with no trim.
- F. Cabinet Trim Material: Stainless steel sheet.
- G. Door Material: Stainless steel sheet.
- H. Door Style: Vertical duo panel with frame.
- I. Door Glazing: Acrylic sheet.
 - 1. Acrylic Sheet Color: Clear transparent acrylic sheet.

- J. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated.
- K. Accessories:
 - 1. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to fire-protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
- L. Materials:
 - 1. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304.
 - a. Finish: ASTM A480/A480M No. 4 directional satin finish.
 - 2. Transparent Acrylic Sheet: ASTM D4802, Category A-1 (cell-cast sheet), 6 mm thick, with Finish 1 (smooth or polished).

2.03 FABRICATION

- A. Fire-Protection Cabinets: Provide manufacturer's standard box (tub) with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated.
 - 1. Weld joints and grind smooth.
 - 2. Miter corners and grind smooth.
 - 3. Provide factory-drilled mounting holes.
- B. Cabinet Doors: Fabricate doors according to manufacturer's standards, from materials indicated and coordinated with cabinet types and trim styles.
 - 1. Fabricate door frames with tubular stiles and rails and hollow-metal design, minimum 1/2 inch (13 mm) thick.
 - 2. Fabricate door frames of one-piece construction with edges flanged.
 - 3. Miter and weld perimeter door frames and grind smooth.
- C. Cabinet Trim: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.

2.04 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM's AMP 500, "Metal Finishes Manual for Architectural and Metal Products," for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces of fire-protection cabinets from damage by applying a strippable, temporary protective covering before shipping.

- C. Finish fire-protection cabinets after assembly.
- D. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine walls and partitions for suitable framing depth and blocking where semirecessed cabinets will be installed.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Prepare recesses for semirecessed fire-protection cabinets as required by type and size of cabinet and trim style.

3.03 INSTALLATION

- A. General: Install fire-protection cabinets in locations and at mounting heights indicated or, if not indicated, at heights acceptable to authorities having jurisdiction.
- B. Fire-Protection Cabinets: Fasten cabinets to structure, square and plumb.
 - 1. Unless otherwise indicated, provide recessed fire-protection cabinets. If wall thickness is inadequate for recessed cabinets, provide semirecessed fire-protection cabinets.
 - 2. Fasten mounting brackets to inside surface of fire-protection cabinets, square and plumb.

3.04 ADJUSTING AND CLEANING

- A. Remove temporary protective coverings and strippable films, if any, as fire-protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.
- B. Adjust fire-protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.
- C. On completion of fire-protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.

- D. Touch up marred finishes, or replace fire-protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire-protection cabinet and mounting bracket manufacturers.
- E. Replace fire-protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 10 44 16
FIRE EXTINGUISHERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher and mounting brackets.

1.03 INFORMATIONAL SUBMITTALS

- A. Warranty: Sample of special warranty.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire extinguishers to include in maintenance manuals.

1.05 COORDINATION

- A. Coordinate type and capacity of fire extinguishers with fire-protection cabinets to ensure fit and function.

1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of hydrostatic test according to NFPA 10 when testing interval required by NFPA 10 is within the warranty period.
 - b. Faulty operation of valves or release levers.
 - 2. Warranty Period: Six years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."
- B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
 - 1. Provide fire extinguishers approved, listed, and labeled by FM Global.

2.02 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

- A. Fire Extinguishers: Type, size, and capacity for each fire-protection cabinet and mounting bracket indicated.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Babcock-Davis.
 - b. Badger Fire Protection; a Carrier company.
 - c. Buckeye Fire Equipment Company.
 - d. Fire-End & Croker Corporation.
 - e. Guardian Fire Equipment, Inc.
 - f. J. L. Industries, Inc.; Activar Construction Products Group, Inc.
 - g. Kidde; Carrier Global Corporation.
 - h. Larsen's Manufacturing Company.
 - i. Nystrom, Inc.
 - j. Potter Roemer LLC; a Division of Morris Group International.
 - 2. Source Limitations: Obtain fire extinguishers and accessories, from single source from single manufacturer.
 - 3. Valves: Nickel-plated, polished-brass body.
 - 4. Handles and Levers: Stainless steel.

5. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B.
 - B. Multipurpose Dry-Chemical Type in Aluminum Container: UL-rated 4-A:60-B:C, 10-lb (4.5-kg) nominal capacity, with monoammonium phosphate-based dry chemical in enameled-aluminum container.
- 2.03 MOUNTING BRACKETS
- A. Mounting Brackets: Manufacturer's standard galvanized steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or red baked-enamel finish.
 1. Source Limitations: Obtain mounting brackets and fire extinguishers from single source from single manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine fire extinguishers for proper charging and tagging.
 1. Remove and replace damaged, defective, or undercharged fire extinguishers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.
- B. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.
 1. Mounting Height: Top of fire extinguisher to be at 42 inches (1067 mm) above finished floor.

END OF SECTION

SECTION 10 51 13

METAL LOCKERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Welded corridor lockers.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of metal locker.

B. Shop Drawings: For metal lockers.

1. Include plans, elevations, sections, and attachment details.

C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available.

D. Samples for Verification: For the following products, in manufacturer's standard size:

1. Lockers and equipment.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For adjusting, repairing, and replacing locker doors and latching mechanisms to include in maintenance manuals.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver metal lockers until spaces to receive them are clean, dry, and ready for their installation.

1.06 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of recessed openings by field measurements before fabrication.

1.07 COORDINATION

- A. Coordinate sizes and locations of concrete or masonry bases for metal lockers.
- B. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of work specified in other Sections to ensure that metal lockers can be supported and installed as indicated.

1.08 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of metal lockers that fail in materials or workmanship, excluding finish, within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation of latches and other door hardware.
 - 2. Damage from deliberate destruction and vandalism is excluded.
 - 3. Warranty Period for Welded Metal Lockers: Lifetime from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain metal lockers and accessories from single source from single locker manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: For lockers indicated to be accessible, comply with applicable provisions in the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

2.03 WELDED CORRIDOR LOCKERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. AJW Architectural Products.
 2. ASI Storage Solutions.
 3. Penco Products, Inc.
 4. Republic Storage Systems, LLC.
- B. Doors: One piece; fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; formed into channel shape with double bend at vertical edges and with right-angle single bend at horizontal edges.
1. Reinforcement: Manufacturer's standard reinforcing angles, channels, or stiffeners for doors more than 15 inches (381 mm) wide; welded to inner face of doors.
 2. Door Style: Vented panel as follows:
 - a. Louvered Vents: No fewer than six louver openings at top and bottom for single-tier lockers.
- C. Body: Assembled by welding body components together. Fabricate from unperforated steel sheet with thicknesses as follows:
1. Tops, Bottoms, and Sides: 0.060-inch (1.52-mm) nominal thickness.
 2. Backs: 0.048-inch (1.21-mm) nominal thickness.
 3. Shelves: 0.060-inch (1.52-mm) nominal thickness, with double bend at front and single bend at sides and back.
- D. Frames: Channel formed; fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet; lapped and factory welded at corners; with top and bottom main frames factory welded into vertical main frames. Form continuous, integral, full-height door strikes on vertical main frames.
1. Cross Frames between Tiers: Channel formed and fabricated from same material as main frames; welded to vertical main frames.
- E. Hinges: Welded to door and attached to door frame with no fewer than two factory-installed rivets per hinge that are completely concealed and tamper resistant when door is closed; fabricated to swing 180 degrees.
1. Hinges: Manufacturer's standard, steel, continuous or knuckle type.
- F. Recessed Door Handle and Latch: Stainless steel cup with integral door pull, recessed so locking device does not protrude beyond door face; pry and vandal resistant.
1. Single-Point Latching: Nonmoving latch hook with steel padlock loop that projects through recessed cup and is finished to match metal locker body.

- a. Latch Hook: Equip each door with one latch hook, fabricated from 0.120-inch (3.04-mm) nominal-thickness steel sheet; welded midway up full-height door strike; with resilient silencer.
- G. Identification Plates: Manufacturer's standard, etched, embossed, or stamped aluminum plates, with numbers and letters at least 3/8 inch (9 mm) high.
- H. Hooks: Manufacturer's standard ball-pointed, aluminum or steel; zinc plated.
- I. Continuous Sloping Tops: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet, with a pitch of approximately 20 degrees.
 - 1. Closures: Vertical-end type.
- J. Recess Trim: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
- K. Filler Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
- L. Materials:
 - 1. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B; with A60 (ZF180) zinc-iron, alloy (galvannealed) coating designation.
- M. Finish: Baked enamel or powder coat.
 - 1. Color: As selected by Engineer from manufacturer's full range.

2.04 FABRICATION

- A. Fabricate metal lockers square, rigid, without warp, and with metal faces flat and free of dents or distortion. Make exposed metal edges safe to touch and free of sharp edges and burrs.
 - 1. Form body panels, doors, shelves, and accessories from one-piece steel sheet unless otherwise indicated.
 - 2. Provide fasteners, filler plates, supports, clips, and closures as required for complete installation.
- B. Fabricate each metal locker with an individual door and frame; individual top, bottom, and back; and common intermediate uprights separating compartments.
- C. Equipment: Provide each locker with an identification plate and the following equipment:
 - 1. Single-Tier Units: Shelf, one double-prong ceiling hook, and two single-prong wall hooks.
- D. Welded Construction: Factory preassemble metal lockers by welding all joints, seams, and connections; with no bolts, nuts, screws, or rivets used in assembly of main locker groups.

Factory weld main locker groups into one-piece structures. Grind exposed welds smooth and flush.

E. Accessible Lockers: Fabricate as follows:

1. Locate bottom shelf no lower than 15 inches (381 mm) above the floor.
2. Where hooks, coat rods, or additional shelves are provided, locate no higher than 48 inches (1219 mm) above the floor.

F. Continuous Sloping Tops: Fabricated in lengths as long as practical, without visible fasteners at splice locations; finished to match lockers.

1. Sloping-top corner fillers, mitered.

G. Recess Trim: Fabricated with minimum 2-1/2-inch (64-mm) face width and in lengths as long as practical; finished to match lockers.

H. Filler Panels: Fabricated in an unequal leg angle shape; finished to match lockers. Provide slip-joint filler angle formed to receive filler panel.

2.05 ACCESSORIES

A. Fasteners: Zinc- or nickel-plated steel, slotless-type, exposed bolt heads; with self-locking nuts or lock washers for nuts on moving parts.

B. Anchors: Material, type, and size required for secure anchorage to each substrate.

1. Provide toothed-steel or lead expansion sleeves for drilled-in-place anchors.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine walls and floors or support bases, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install lockers level, plumb, and true; shim as required, using concealed shims.

1. Anchor locker runs at ends and at intervals recommended by manufacturer, but not more than 36 inches (910 mm) o.c. Using concealed fasteners, install anchors through backup reinforcing plates, channels, or blocking as required to prevent metal distortion.
- B. Welded Lockers: Connect groups together with manufacturer's standard fasteners, with no exposed fasteners on face frames.
- C. Equipment:
 1. Attach hooks with at least two fasteners.
 2. Attach door locks on doors using security-type fasteners.
 3. Identification Plates: Attach plates to each locker door, near top, centered, with at least two aluminum rivets.
- D. Trim: Fit exposed connections of trim, fillers, and closures accurately together to form tight, hairline joints, with concealed fasteners and splice plates.
 1. Attach recess trim to recessed metal lockers with concealed clips.
 2. Attach filler panels with concealed fasteners. Locate filler panels where indicated on Drawings.
 3. Attach sloping-top units to metal lockers, with closures at exposed ends.

3.03 ADJUSTING

- A. Clean, lubricate, and adjust hardware. Adjust doors and latches to operate easily without binding.

3.04 PROTECTION

- A. Protect metal lockers from damage, abuse, dust, dirt, stain, or paint. Do not permit use during construction.
- B. Touch up marred finishes, or replace metal lockers that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by locker manufacturer.

END OF SECTION

SECTION 11 11 36

VEHICLE CHARGING EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. AC Level 2 electric vehicle supply equipment.

B. Products Installed, but Not Furnished, under This Section:

1. Section 26 05 29
2. Section 26 05 53

C. Reference:

1. Section 28 10 00

1.02 DEFINITIONS

- A. CCS: Combined charging system; a means for using the same connector port for both AC Level 2 charging and DC Level 2 fast charging.
- B. EV: Electric vehicle.
- C. EVCE: Electric vehicle charging system equipment. This term refers to DC Level 2 charging equipment located off-board the vehicle.
- D. EVSE: Electric vehicle supply equipment. This term refers to AC Level 2 charging equipment that depends on the built-in charger located onboard the vehicle.
- E. Fastened in Place: Does not require tools to be removed and replaced.
- F. Fixed in Place: Requires tools to be removed and replaced.
- G. OCPP: Open Charge Point Protocol; an application protocol for communication between EVs and a central management system.

1.03 ACTION SUBMITTALS

A. Product Data:

1. AC Level 2 EVSE.

- B. Shop Drawings:
 - 1. Routing and attachment of permanent wiring for AC Level 2 EVSE.
- C. Field quality-control reports.
- D. Sustainable design submittals.

1.04 INFORMATIONAL SUBMITTALS

- A. Preconstruction test reports.
- B. Manufacturers' Published Instructions:
 - 1. AC Level 2 EVSE.
- C. Manufacturer's Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts:
 - 1. Software and firmware service agreement.
- B. Warranty documentation.

1.06 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts:
 - 1. UL FFWA - AC Level 2 EV charging station and accessories.
 - 2. UL FFWA - A Level 2 EV supply equipment (EVSE).
- B. Special Tools:
 - 1. UL FFWA - AC Level 2 EV charging station and accessories.
 - 2. UL FFWA - AC Level 2 EV supply equipment (EVSE).

1.07 PRECONSTRUCTION TESTING

- A. Preconstruction Test Reports: Collect, assemble, and submit test reports prepared by qualified testing agency.

1.08 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed vehicle charging equipment performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.01 AC LEVEL 2 ELECTRIC VEHICLE SUPPLY EQUIPMENT

- A. Description: EVSE with input rated up to 600 V(ac) for AC Level 2 charging of vehicle batteries using the EV's onboard charger.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. EV Supply Equipment: UL CCN FFWA; including UL 2594.
 - b. Personnel Protection: UL CCN FFUQ2; including UL 2231-1 and UL 2231-2.
 - 3. General Characteristics: Complying with Article 625 of NFPA 70.
- C. UL FFWA - AC Level 2 EV Charging Station and Accessories:
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. West Side Units (Back of Building) Options:
 - a. Location Rating: Outdoor.
 - b. Input Feeder Rating: 208 to 240 V(ac), single phase, 60 Hz, dual 9.6 kW (50 A).
 - c. Output Quantity: 2.
 - d. Output Wiring: Flexible cord.
 - (1) Output Cable Nominal Length: 18 ft.

- (2) Cable management system.
 - (3) Output Attachment Plug: Type 1 (SAE J1772).
 - e. Mounting: Wall mount as indicated on Drawings.
 - f. Metering: Nonrevenue grade meter.
 - g. Networking:
 - (1) Protocol: Modbus TCP/IP.
 - (2) LAN Communications: Ethernet.
 - (3) Capable of remote configuration and reporting.
 - h. Authorization or Payment System:
 - (1) Proximity card reader in accordance with Section 28 10 00
 - (2) PCI compliant.
 - (3) Capable of remote control and authorization.
3. East Side Units (Front of the Building) Options:
- a. Location Rating: Outdoor.
 - b. Input Feeder Rating: 208 to 240 V(ac), single phase, 60 Hz, dual 9.6 kW (50 A).
 - c. Output Quantity: 2.
 - d. Output Wiring: Flexible cord.
 - (1) Output Cable Nominal Length: 18 ft.
 - (2) Cable management system.
 - (3) Output Attachment Plug: Type 1 (SAE J1772).
 - e. Mounting: Pedestal mount as indicated on Drawings.
 - f. Metering: Revenue grade meter.
 - g. Networking:
 - (1) Protocol: OCPP.
 - (2) LAN Communications: Ethernet.

- (3) Capable of remote configuration and reporting.
 - h. Authorization or Payment System:
 - (1) Credit card reader.
 - (2) PCI compliant.
 - (3) Capable of remote control and authorization.
- 4. Accessories:
 - a. Spare Parts: Furnish to Owner spare parts, for repairing vehicle charging equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.
 - b. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to vehicle charging equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine walls, floors, and bollards or posts for suitable conditions where vehicle charging equipment will be installed.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF VEHICLE CHARGING EQUIPMENT

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation:
 - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with Article 625 of NFPA 70 and with NECA NEIS 413.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Fastened in Place: Comply with manufacturer's published instructions for installing mounting hardware.

2. Fixed in Place: Comply with manufacturer's published instructions for installation and torquing of hardware fasteners.
3. Base Mounting: When indicated on Drawings or in manufacturer's published instructions, provide housekeeping pad for installing base for vehicle charging equipment.
4. Identification: Provide labels for vehicle charging equipment and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - c. Label each enclosure with engraved metal or laminated-plastic nameplate.

D. Cybersecurity:

1. Software:
 - a. Coordinate security requirements with IT department.
 - b. Ensure that latest stable software release is installed and properly operating.
 - c. Disable or change default passwords to password of at least eight characters in length, using a combination of uppercase and lower letters, numbers, and symbols. Record passwords and turn over to party responsible for system operation and administration.
2. Hardware:
 - a. Coordinate location and access requirements with IT department.
 - b. Enable highest level of wireless encryption that is compatible with Owner's information and communications technology network.
 - c. Disable dual network connections.

3.03 FIELD QUALITY CONTROL OF VEHICLE CHARGING EQUIPMENT

- A. Field tests and inspections must be witnessed by field Representative.
- B. Tests and Inspections:
 1. Perform manufacturer's recommended tests and inspections.
 2. For each unit of vehicle charging equipment, perform the following tests and inspections:

- a. Unit self-test.
 - b. Operation test with EV.
 - c. Network communications test.
- C. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- E. Manufacturer Services: Engage factory-authorized service representative to supervise field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare report after each visit by factory-authorized service representative, documenting activities performed at Project site.
- 3.04 SYSTEM STARTUP
 - A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 - B. Manufacturer Services: Engage factory-authorized service representative to supervise system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.
- 3.05 PROTECTION
 - A. After installation, protect vehicle charging equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- 3.06 MAINTENANCE
 - A. Software and Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for two years.

2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within two years from date of Substantial Completion.
 - a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system.
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION

SECTION 11 24 29

FACILITY FALL PROTECTION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Rooftop Fall Protection System equipment including:
 - a. System design
 - b. Tieback anchors
 - c. Davits
2. Ladder fall arrest systems.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review sequence of operation for each type of equipment.
2. Review required testing, inspecting, and certifying procedures.

1.03 ACTION SUBMITTALS

A. Product Data: Manufacturers' data and product information for manufactured materials and products:

1. Test report certified by a professional engineer
2. General product data
3. Detailed drawings of equipment proposed
4. Installation instructions

B. Shop Drawings: For fabrication and erection.

1. Submit scaled shop drawings showing location plan of all support equipment and sections detailing all parts and accessories.
2. Clearly specify equipment dimensions, materials, fabrication details, hardware, and installation instructions.

3. Include notes with guidelines of proper use of system.
4. Equipment location plan to include identification number next to each piece of equipment that are permanently affixed to a structure.
5. Shop drawings shall be prepared under supervision of a registered professional engineer and shall bear engineer's seal and signature. Professional engineer shall be licensed in jurisdiction where project is located. Include P.E. certified report of tested equipment.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Provide documentation verifying company's amount of experience and successful performance in design, fabrication, and installation of permanent window washing fall protection equipment.
 1. Submit listing of company's installations representing similar scope and complexity to project requirements for previous 10 years. List shall include information as follows:
 - a. Project name and address.
 - b. Name of Owner.
 - c. Name of Contractor.
 - d. Name of Engineer.
 - e. Date of completion.
 2. Provide documentation verifying that installers have been trained by the manufacturer and are competent.
- B. Delegated Design Submittal: Design of the fall protection system shall be performed by an Engineer with experience in designing not less than 5 installations of similar size and scope.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fall protection systems to include in operation and maintenance manuals.
 1. Submit operations & maintenance guidance in accordance with the requirements of Division 01.

1.06 QUALITY ASSURANCE

- A. Manufacturer/Installer Qualifications: Provide products from a company specializing in design, fabrication, and installation of permanent suspended access equipment with a

minimum of 5 years documented experience. Companies like miscellaneous metal fabricators not normally engaged in design and fabrications of suspended access equipment are not acceptable.

1. Manufacturer and installer shall have specific liability insurance (products and completed operations) in an amount not less than \$5,000,000.
 2. Installer(s) shall be trained or qualified by manufacturer in installation techniques and procedures of permanent suspended access equipment.
- B. In order to assure uniform quality, ease of maintenance and minimal parts storage, it is the intent of these Specifications that all equipment called for under this Section shall be supplied by a single source. The equipment supplier shall, in addition to the installer, assume the responsibility for proper and complete installation.
- 1.07 DELIVERY, STORAGE, AND HANDLING
- A. Deliver materials in manufacturer's original, unopened protective packaging.
 - B. Store materials in original protective packaging. Prevent soiling, physical damage or wetting.
- 1.08 FIELD CONDITIONS
- A. Field Measurements: Perform prior to preparation of Shop Drawings and fabrication drawings to ensure required fit and dimensions.

PART 2 - PRODUCTS

2.01 EXTERIOR ROOF-TOP SYSTEM DESCRIPTION

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Fall Protection System by Summit Anchor Company, www.summitanchor.com
 1. Substitutions: Engineer will consider products of comparable manufacturers as a substitution, pending the contractor's submission of adequate documentation of the substitution in accordance with procedures in Division 1 of the Project Manual.
- B. Anchorage Design Requirements:
 1. Safety anchor system design shall comply with current OSHA, ANSI, and local regulations pertaining to window cleaning and fall protection.
 2. Anchor system shall provide independent fall arrest anchorages as required by OSHA and ANSI requirements, and as shown on Drawings.

C. Davit Design Requirements:

1. Davits shall be capable of supporting an ultimate load of not less than 4 times the rated load. The rated load of the davit shall be based on the swing stage hoist and powered platform load capacity, which is frequently 1,000 lbs or more.
2. Manufacture shall provide engineer's calculations and test report to verify that davit will support load requirements.

2.02 STRUCTURAL COMPONENT MATERIALS

A. Exposed Structural Components Finish: Galvanized Mild Steel or Stainless Steel

1. Steel: ASTM A572 GR 50
2. Steel: ASTM A A36
3. Galvanizing: ASTM A123
4. Stainless Steel; 304 ASTM A 193 Grade B8, Class 2
5. Aluminum; 6061-T6 Alloy

B. Yield Strength

1. Base Plates and Bottom Plates, High Strength Steel: 50 ksi minimum
2. Other Sections: 36 ksi minimum

C. Non-Structural Components

1. Aluminum; 6061-T6 Alloy
2. Alloys shall conform to requirements published in AA Aluminum Standards.
3. Sheet and Plate: ASTM B209
4. Extruded Bars, Rods, Shapes, and Tubes: ASTM B221

D. Hollow Structural Sections (HSS)

1. ASTM A500, Grade C
2. Yield Strength: 46 ksi minimum (round shapes) and 50 ksi (square and rectangular shapes)
3. Tensile Strength: 62 ksi minimum

E. Round Pipe Sections

1. ASTM A53, Grade B
2. Yield Strength: 35 ksi minimum
3. Tensile Strength: 60 ksi minimum

F. Nuts, Bolts, Davit Pins, and Washers

1. Stainless Steel; 304 ASTM A 193 Grade B8 or F593C
2. Galvanized Flat Washers ASTM F-436 or 18 -8 Stainless Steel

G. Anchor Bolts, for securing base plate

1. Metal: Stainless Steel, 304 Stainless Steel; ASTM A 193 Grade 8, B8
2. Size: 5/8 in. diameter minimum

2.03 MANUFACTURED UNITS

A. Anchor:

1. Capable of withstanding 5000 lbs. (2268kg) in any direction without permanent deflection.
2. Anchor eye size: Not less than $\frac{3}{4}$ inch (20 mm) diameter material with 2 $\frac{1}{4}$ in (60 mm) eye opening.
3. Anchor eye metals:
 - a. Forged, 1030 quenched and tempered per ASTM 576-90-b, 72 ksi minimum.
 - b. Forged Stainless steel, type 304, solution annealed, 35 ksi minimum.
4. Anchor tube height: not less than 4 in. above the finished roof.

B. Davit Base:

1. Stanchion type complete with davit adapter and lock pin with stainless steel safety snap pin.
2. Davit socket; with two stainless steel hinge pins and self-locking ring-snap pins.
3. Pier Height: generally not less than 8 in. above finished roof surface to allow proper fit up with adaptor.

C. Flashing:

1. EPDM gasket seal top and base.
2. Seamless Spun Aluminum Flashing: ASTM B221; Type 6061-T6 alloy.
3. Stainless Steel: 304.

D. Cast-in-Place Equipment:

1. A minimum of two cast-in-place steel studs are required for concrete embedded anchors.

2.04 LADDER FALL ARREST SYSTEM

A. Manufacturers: Subject to compliance with requirements, products from the following:

1. MSA Latchways, www.latchways.com.
2. Fall Arrest Protection Systems by DBI-SALA, a 3M company
3. Substitutions: Engineer will consider products of comparable manufacturers as a substitution, pending the contractor's submission of adequate documentation of the substitution in accordance with procedures in Division 1 of the Project Manual.

B. Provide complete system including flexible cable system, ladder rung attachments, ladder extension post, where shown on drawings, and detachable cable sleeve.

C. Weight Capacity: 310 lbs maximum.

D. Loading Requirements for Structure: The climbing structure to which the ladder fall arrest system is installed must be capable of supporting the total loading imposed by the system.

2.05 FABRICATION

A. Fabricate work true to dimension, square, plumb, level, and free from distortion or defects detrimental to appearance and performance.

B. Grind off surplus welding material to ensure exposed surfaces are smooth so as not to abrade workers' ropes.

C. Welding shall be in accordance with the AWS Structural Welding Code D1.1/D1.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Report to general contractor any conditions that deviate from shop drawings or any defects in workmanship that would cause an unsafe installation. This report shall be verified in writing to the general contractor and any other responsible party.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install in accordance with approved shop drawings and manufacturer's instructions.
- B. Install anchorages and fasteners in accordance with manufacturer's recommendations and instructions to obtain the allowable working loads published in the product literature and instructions and in accordance with this specification. Do not load or stress fall protection system until all materials and fasteners are properly installed and ready for service.

3.03 FIELD QUALITY CONTROL

- A. Inspection and Site Visits:
 - 1. Inspections and site visits shall be performed while installation of equipment is in progress under the supervision of qualified professional engineer registered in the jurisdiction where the project is located.
 - 2. On site inspection of equipment welded to structure shall be performed by an AWS Certified Welding Inspector verifying, in writing, size and quality of welds. Such an inspection shall be performed on each piece of equipment before roofing material is installed.
 - 3. On site inspection shall be performed on all cast in place items while being tied in with the rebar with sufficient time before concrete is poured to allow to adjustments to embedded items as recommended by inspector.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment.

END OF SECTION

SECTION 11 30 13

APPLIANCES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Cooking appliances.
2. Refrigeration appliances.
3. Cleaning appliances.
4. Lab appliances.

B. Related Requirements:

1. Refer to Division 01 section for equipment and appliances that are part of the Lab Equipment allowance.

1.02 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

1. Include installation details, material descriptions, dimensions of individual components, and finishes for each appliance.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.

B. Product Schedule: For appliances.

1.03 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of appliance.

B. Field quality-control reports.

C. Sample Warranties: For manufacturers' special warranties.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each residential appliance to include in operation and maintenance manuals.

1.05 WARRANTY

- A. Special Warranties: Manufacturer agrees to repair or replace appliances or components that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain each type of appliance from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Electrical Appliances: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 COOKING APPLIANCES

- A. Microwave Oven:

- 1. Type: Conventional.
 - 2. Dimensions: As indicated on Drawings.
 - 3. Oven Door: Door with observation window and pull handle.
 - 4. Exhaust Fan: Variable-speed fan, nonvented, recirculating type with charcoal filter and with manufacturer's standard capacity.
 - 5. Microwave Power Rating: 1000 W.
 - 6. Electric Power Supply: 120 V, 60 Hz, 1 phase, 15 A.
 - 7. Controls: Digital panel controls and timer display.
 - 8. Other Features: Turntable.
 - 9. Material: Porcelain-enameled steel or Stainless steel.

2.04 REFRIGERATION APPLIANCES

- A. Refrigerator/Freezer: Two-door refrigerator/freezer with freezer on top and complying with AHAM HRF-1.

- 1. Type: Freestanding.

2. Dimensions: As indicated on Drawings.
3. Storage Capacity:
 - a. Refrigeration Compartment Volume: 15.6 cu. ft. (0.44 cu. m).
 - b. Freezer Volume: 5.13 cu. ft. (0.15 cu. m).
4. Refrigerator Features:
 - a. Interior light in refrigeration compartment.
 - b. Door Storage: Modular compartments.
 - c. Temperature-controlled meat/deli bin.
5. Freezer Features: One freezer compartment with door.
 - a. Interior light in freezer compartment.
 - b. Automatic icemaker and storage bin.
6. Energy Star: Provide appliances that qualify for the EPA/DOE Energy Star product-labeling program.
7. Appliance Color/Finish: White or Stainless steel.

2.05 CLEANING APPLIANCES

A. Dishwasher: Complying with AHAM DW-1.

1. Type: Built-in undercounter.
2. Dimensions: As indicated on Drawings.
3. Capacity:
 - a. International Place Settings of China: Eight
 - b. Water Consumption for Full Load: 3.2 gal. (12 L) per cycle.
4. Sound Level: Maximum 42 dB.
5. Tub and Door Liner: Porcelain-enameled steel **or** Stainless steel with sealed detergent and automatic rinsing-aid dispensers.
6. Rack System: Nylon-coated sliding dish racks, with removable cutlery basket.

7. Controls: Touch-pad controls with four wash cycles and hot-air and heat-off drying cycle options.
8. Features:
 - a. Waste food disposer.
 - b. Self-cleaning food-filter system.
 - c. Half-load option.
 - d. Delay-wash option.
 - e. Digital display panel.
9. Energy Star: Provide appliances that qualify for the EPA/DOE Energy Star product-labeling program.
10. Appliance Color/Finish: White **or** Stainless steel.

2.06 LAB APPLIANCES

A. Dishwasher:

1. Basis-of-Design: Subject to compliance with the requirements, provide Fisher Scientific Undercounter Glassware Washer, or comparable product as approved by Engineer.
2. All models come with removable top and bottom stainless-steel open racks to accommodate a variety of glassware
3. Spindle rack ready models accommodate direct injection spindle racks (sold separately) for thorough cleaning inside narrow-neck glassware
4. Stainless steel baskets, insert racks and accessories sold separately to maximize space, improve efficiency, and protect specialty glassware
5. Temperature selection to 70°C (158°F); can effectively dissolve stubborn oils
6. DI rinse ensure a spotless finish; easily connect to fixed or portable DI water systems
 - a. Provide DI Booster Pump if incoming DI water source has a pressure of less than 18psi
7. Delayed start feature enables washer to operate unattended during off-peak hours to reduce energy costs
8. Designed for optimal quiet operation with noise buffering insulation

9. Three filters protect pumps from debris; conveniently located for easy access
10. Minimal, efficient water consumption
11. Enhanced dual fan drying system for spotless results
12. 304 stainless steel chamber ensures corrosion protection and long life
13. Adjustable leveling legs
14. UL 61010-1 & CSA 22.2 61010-1 certified by MET Labs
15. Microprocessor control system features 6 cycle selections including a customizable timed option to ensure minimum energy consumption. All wash cycles have pre-wash, wash, pre-rinse and rinse cycles to prevent contamination.
16. Appliance Color/Finish: Stainless steel.

2.07 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, power connections, and other conditions affecting installation and performance of residential appliances.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before appliance installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install appliances according to manufacturer's written instructions.

- B. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and that rough openings are completely concealed.
- C. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.

3.03 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform visual, mechanical, and electrical inspection and testing for each appliance according to manufacturers' written recommendations. Certify compliance with each manufacturer's appliance-performance parameters.
 - 2. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After installation, start units to confirm proper operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.
- B. An appliance will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain residential appliances.

END OF SECTION

SECTION 11 53 13

LABORATORY FUME HOODS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Bench-top High-Performance Laboratory Fume Hoods.
2. Service fixtures (i.e., water, gas, etc.) and electrical service fittings in fume hoods.
3. Piping and wiring within service fittings, light fixtures, switches, and other electrical devices.
4. Fume hood base support.
5. Work Surfaces within fume hoods.
6. Filler panels and ceiling enclosures for fume hoods.

1.02 COORDINATION

- ###### A.
- Coordinate installation of fume hoods with laboratory casework and other laboratory equipment.

1.03 ACTION SUBMITTALS

- ###### A.
- Product Data: For each type of product.

- ###### B.
- Shop Drawings: For laboratory fume hoods.

1. Include plans, elevations, sections, and attachment details.
2. Indicate details for anchoring fume hoods to permanent building construction including locations of blocking and other supports.
3. Indicate locations and types of service fittings together with associated service supply connection required.
4. Indicate duct connections, electrical connections, and locations of access panels.
5. Include roughing-in information for mechanical, plumbing, and electrical connections.

6. Show adjacent walls, doors, windows, other building components, laboratory casework, and other laboratory equipment. Indicate clearances from the above items.
7. Include layout of fume hoods in relation to lighting fixtures and air-conditioning registers and grilles.
8. Include coordinated dimensions for laboratory equipment specified in other Sections.

1.04 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Showing compliance with specified performance requirements for as-manufactured containment and static pressure loss, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency.
- B. Field quality-control reports.

1.05 QUALITY ASSURANCE

- A. Manufacturer's Qualifications:
 1. ISO 9001 Certified manufacturing plant and processes.
 2. Ten installations of equal or larger size and requirements. Provide contact at each.
- B. Fume hoods shall be Made in America
 1. 95% or more of raw material and component suppliers shall be United States based.
 2. Stainless and cold rolled steel used in manufacturing shall be sourced from United States steel mills.
 3. Final product must be fabricated and assembled within the United States of America.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect finished surfaces during handling and installation with protective covering of polyethylene film or another suitable material.

1.07 FIELD CONDITIONS

- A. Environmental Limitations: Do not deliver or install fume hoods until building is enclosed, wet work and utility roughing-in are complete, and HVAC system is operating and maintaining temperature and relative humidity at occupancy levels during the remainder of the construction period.

- B. Locate concealed framing, blocking, and reinforcements that support fume hoods by field measurements before being enclosed, and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain laboratory fume hoods from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. General Design Requirements:

1. Fume hoods shall function as ventilated, enclosed workspaces, designed to capture, contain and exhaust fumes, vapors and particulate matter produced or generated within the enclosure.
2. Fume hood shall be factory designed to function as a by-pass fume hood or as a variable air volume fume hood without modification.
3. Structure and Materials of construction
 - a. Hoods are of double-wall construction
 - b. Powder-coated, cold rolled steel exterior
 - c. Galvanized steel support members
 - d. Sheet molded composite panel internal liner
4. Baffles
 - a. Perforated primary baffle designed to pull air in horizontal streams to minimize the air roll pattern associated with traditional fume hoods.
 - b. Baffle slot pattern designed to optimize face velocity profile.
 - c. Secondary baffle is located behind the primary perforated baffle to counteract upward air streams that produce roll.
 - d. Moving or adjustable baffles are not acceptable
5. Sash
 - a. Maximum opening is 28-inches.
 - b. Unobstructed viewing height is 37.5-inches.

- c. Hood incorporates a perforated sash handle to bleed air into the hood chamber directing fume concentrations away from the user's breathing zone.
- 6. Airfoil: Hoods are provided with an airfoil across the bottom of the sash area that allows airflow into the hood regardless of user's position.
- 7. Hoods are provided with an upper dilution air supply for by-pass air to bathe the sash interior and upper interior and to provide 5-10% of the hood's air volume requirements.
- 8. Besides the exhaust blower, no additional blowers are required for specified containment.
- 9. Access for maintenance is from both the front, interior, and exterior sides of the hood.
- 10. Services:
 - a. Furnish and deliver all service outlets, accessory fittings, electrical receptacles and switches, as listed in these specifications, equipment schedules or as shown on drawings.
 - b. Plumbing fittings mounted on the fume hood superstructures shall be pre-plumbed.
 - c. All electrical services are pre-wired to a single point internal junction box at the top right of the hood.
- 11. Hoods without service fixtures must pass through a 38" opening without disassembly.
- B. Containment: Provide fume hoods that comply with the following when tested according to ASHRAE 110 as modified below:
 - 1. As-Manufactured (AM) Rating: AM 0.01 (0.01 ppm).
 - 2. Average Face Velocity: 100 fpm (0.51 m/s) plus or minus 10 percent with sashes fully open.
 - 3. Face-Velocity Variation: Not more than 10 percent of average face velocity across the face opening with sashes fully open.
 - 4. Sash Position: Fully open.
 - a. Test hoods with horizontal sashes with maximum opening on one side, with maximum opening in the center, and with one opening at each side equal to half of maximum opening.

- b. Test hoods with combination sashes fully raised, with maximum opening on one side, with maximum opening in the center, and with one opening at each side equal to half of maximum opening.
- 5. Release Rate: 4.0 L/min.
- 6. Test Setup Modifications: Conduct tests with a minimum of three and a maximum of five people in the test room and with two 1-gal. (3.8-L) round paint cans, one 12-by-12-by-12-inch (300-by-300-by-300-mm) cardboard box, and three 6-by-6-by-12-inch (150-by-150-by-300-mm) cardboard boxes in the fume hood during the test. Position items from 6 to 10 inches (150 to 250 mm) behind the sash, randomly distributed, and supported off the work surface by 2-by-2-inch (50-by-50-mm) blocks.
- 7. Walk-by Test: At the conclusion of containment test, execute three rapid walk-bys at 30-second intervals, 12 inches (300 mm) behind the mannequin. Test-gas concentration during each walk-by to not exceed 0.1 ppm and to return to specified containment value within 15 seconds.
- C. Static-Pressure Loss: Not more than 1/2-inch wg (124 Pa) at 100-fpm (0.51-m/s) face velocity with sash fully open when measured at four locations 90 degrees apart around the exhaust duct and at least three duct diameters downstream from duct collar.

2.03 FUME HOODS, GENERAL

- A. Product Standards: Comply with SEFA 1, "Laboratory Fume Hoods - Recommended Practices." Provide fume hoods UL listed and labeled for compliance with UL 1805.
- B. Fume Hoods:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Labcono; Protector XStream or a comparable product by one of the following:
 - a. Keur Industries, LLC.
 - b. Kewaunee Scientific Corporation.
 - c. Sheldon Laboratory Systems.

2.04 MATERIALS

- A. Hood Interior Liner and Baffle:
 - 1. Liner material must comply with UL 1805, and be listed within NRTL test report as proof of compliance.
 - 2. General Material Properties:
 - a. Nonflammable, corrosion and chemical-resistant.

- b. Sheet molded homogenous polyester panels.
 - c. Minimum thickness is 3/16-inch.
 - d. Smooth, white finish.
3. Mechanical Properties:
- a. Tensile Strength: 7,500 PSI (51.7 Mpa)
 - b. Tensile Modulus: 1.7×10^6 PSI (11,700 Mpa)
 - c. Flexural Strength: 21,000 PSI (145 Mpa)
 - d. Flexural Strength at 130 degrees C: 12,900 PSI (89 Mpa)
 - e. Compressive Strength: 32,500 PSI (224 Mpa)
 - f. IZOD Impact Strength (Notched): 8.4 Ft Lb/in (4.5 J/cm)
4. Flame and Smoke Characteristics:
- a. Flame retardant, self-extinguishing, with a flame spread rating of 25 or less in accordance with ASTM-E84
 - b. Oxygen Index: 35%
 - c. Smoke Density: 115
5. Physical Properties:
- a. Water Absorption: 0.4%
 - b. Specific Gravity: 4.81
 - c. Coefficient of Thermal Expansion: $2 \text{ in/in/ degree C} \times 10^{-5}$
 - d. Thermal Conductivity: 1.9 BTU/Hr/sq.ft./In/degree F
6. Chemical Resistance:
- a. Required minimum results for each reagent (Reagent: Fume Resistance Rating, Splash and Spill Resistance Rating)
 - (1) Hydrochloric Acid (37%): 2,1
 - (2) Sulfuric Acid (33%): 2,1
 - (3) Sulfuric Acid (77%): 1,1

(4)	Sulfuric Acid (96%):	1,2
(5)	Formic Acid (90%):	2,1
(6)	Nitric Acid (20%):	2,2
(7)	Nitric Acid (30%):	1,2
(8)	Nitric Acid (70%):	3,2
(9)	Hydrofluoric Acid (48%):	2,2
(10)	Phosphoric Acid (85%):	1,1
(11)	Chromic Acid (60%):	1,4
(12)	Acetic Acid (98%):	1,1
(13)	Ammonium Hydroxide (20%):	1,1
(14)	Sodium Hydroxide (10%):	1,1
(15)	Sodium Hydroxide (20%):	1,3
(16)	Sodium Hydroxide (40%):	1,3
(17)	Sodium Hydroxide Flake:	1,-
(18)	Sodium Sulfide:	1,1
(19)	Zinc Chloride:	2,1
(20)	Tincture of Iodine:	3,3
(21)	Silver Nitrate:	2,1
(22)	Methyl Alcohol:	1,1
(23)	Ethyl Alcohol:	1,1
(24)	Butyl Alcohol:	1,1
(25)	Benzene:	1,1
(26)	Xylene:	1,1
(27)	Toluene:	1,1
(28)	Gasoline:	1,1

(29) Dichloro Acetic Acid:	2,2
(30) Dimethyl Formanide:	2,2
(31) Ethyl Acetate:	1,1
(32) Amyl Acetate:	1,1
(33) Acetone:	1,1
(34) Chloroform:	1,1
(35) Carbon Tetrachloride:	1,1
(36) Phenol:	2,2
(37) Cresol:	1,1
(38) Formaldehyde:	1,1
(39) Trichloroethylene:	1,1
(40) Ethyl Ether:	1,1
(41) Furfural:	1,3
(42) Methylene Chloride:	1,1
(43) Mono Chloro Benzene:	1,1
(44) Dioxane:	1,1
(45) Methyl Ethyl Ketone:	1,1
(46) Acid Dichromate:	1,2
(47) Hydrogen Peroxide:	1,1
(48) Napthalene:	1,1

B. Sheet Steel:

1. Side panels and access panels 20-gauge (or heavier) sheet steel.
2. Hood corner posts are 18-gauge sheet steel.
3. Ceiling enclosure panels are 18 gauge sheet steel.
4. Cold-rolled, commercial steel (CS) sheet, complying with ASTM A 1008/A 1008M.

C. Chemical Resistant Finish:

1. General: Prepare, treat, and finish welded assemblies after welding. Prepare, treat, and finish components that are to be assembled with mechanical fasteners before assembling.
2. Chemical and Physical Resistance of Finish System: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8. Third party validation required.
3. Powder-coat process required. Paint processes that release Volatile Organic Compounds (VOC) are not acceptable
4. Color for Fume Hood Finish: Glacier White

D. Glass: Tempered

1. Clarity and temper test to be as specified in latest edition of Glass Tempering Association, Engineering Standards Manual, Section 8.1.
2. Surface and interior visible quality to be as specified per ASTM C 1036, Standard Specification for Flat Glass, Table 4, Quality level Q3.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Fasteners: Provide stainless steel fasteners where exposed to fumes.

2.05 FABRICATION

A. General: Assemble fume hoods in factory to greatest extent possible. Disassemble fume hoods only as necessary for shipping and handling limitations. Fume hoods to be capable of being partly disassembled as necessary to permit movement through door opening.

B. Superstructure:

1. Self-supporting, rigid structural assembly, to support inner wall consisting of fume hood liner and outer wall of sheet metal exterior.
2. Fabricated from galvanized steel.
3. Space shall accommodate fume hood wiring and plumbing components for service fixtures.
4. Access to fixture valves concealed in wall provided by exterior removable access panels, gasket access panels on the inside liner walls, or through removable access panels on the front posts.

C. Exterior:

1. Fabricate from steel sheet with component parts screwed together.
2. Apply chemical-resistant finish to interior and exterior surfaces of component parts before assembly.
3. Interchangeable side panels shall lift off without the use of tools to allow access to plumbing lines, service fittings, electrical wiring, counterbalance sash weights, and light fixtures. Exposed fasteners or hardware, and Velcro type fasteners, are not acceptable.
4. Corner posts:
 - a. Pre-punched and plugged to accommodate up to 4 service fixtures per side.
 - b. All services are accessible from the front of the hood.
 - c. Accommodate two electrical duplexes per side.
 - d. Right hand corner post includes electrical switches and pre-cut for Airflow monitor installation.
 - e. Un-used penetrations shall be plugged.
5. Top and sides of face opening to provide an aerodynamic shape to ensure smooth, even flow of air into fume hood.
6. Panel above header shall be removable without the use of tools to allow access to mechanical connection, electrical wiring, counterbalance sash weights, and light fixtures. Exposed fasteners or hardware, and Velcro type fasteners, are not acceptable.

D. Dimensions:

1. Overall exterior dimensions are as follows:
 - a. 4-foot nominal width: 48-inches w x 59-inches h x 39.2-inches d
2. Overall interior dimensions are as follows:
 - a. 4-foot nominal width: 38.25-inches w x 48-inches h x 27.3-inches d

E. Hood Liner:

1. Adhere interior liner components to superstructure.
2. Stainless steel fasteners shall be used on the interior ceiling for structural integrity.

3. Fasteners exposed to chemical environment are not acceptable.
4. Punch fume hood lining side panels to receive four service fittings, for use with remote controls, per side. Provide removable plug buttons for holes not used for indicated fittings.
5. Each side wall shall include an oval interior access panel to provide access to the side wall of the fume hood for plumbing service access. Access panel material shall be that of the liner, and gasketed to form a vapor proof seal.

F. Hood Baffle:

1. Baffle system shall be designed to optimize the face velocity profile, and to capture a wide range of gaseous densities without adjustment or moving components.
2. Include a two-baffle system.
 - a. Primary baffle: Shall provide a continuous horizontal slot at the work surface. Baffle panels shall have multiple horizontal slots, with a chamfered entry. Slot pattern shall be proven to optimize face velocity profile, and direct air in a non-turbulent/laminar flow stream from the hood face into the baffle in a single pass.
 - b. Secondary baffle: located between the primary baffle and the back wall of the hood, neutralizes any upward air streams and reduce air stream roll.
3. Baffle system shall be constructed with the same material as the fume hood liner.
4. Baffles shall be removable for cleaning. Primary baffles shall be two pieces to allow removal without the use of tools.
5. Exposed components to be non-metallic. Metal components exposed to chemical environment are not acceptable.
6. Moving parts or adjustment of any kind is not acceptable.

G. Exhaust Connection:

1. 316 stainless steel with Chemical-Resistant Finish
2. 12.81-inches ID to accommodate any 12-inch nominal duct without the need for a transition adapter. 4, 5, and 6-foot hoods have one exhaust connection, and 8-foot hoods have two exhaust connections. Additional components required to accommodate 12-inch nominal mechanical system are not acceptable.
3. Ducting shall go inside the duct collar to ensure condensate travels into the hood and evaporates. Duct collars that allow duct connection over the collar are not acceptable.

H. Airfoil:

1. Cold Rolled Steel or 316 stainless steel with Chemical-Resistant Finish.
2. Airfoil shall have an aerodynamic radius to sweep the air into the hood with minimal turbulence. Airfoil directs airflow across work top to remove heavier-than-air gases.
3. Must have 5 rows of perforations to allow the air to bypass underneath and through the foil and sweep across the work surface to prevent any back flow of fumes escaping from the front of the hood opening. This airflow continues even if blocked by the presence of the operator.
4. Foil must extend back under the sash to prevent closure of the lower by-pass opening when the sash is in the fully closed position, directly on top of the airfoil.

I. Sash Assembly

1. Glass: Fully tempered safety glass with unobstructed, side-to-side view of fume hood interior and service fixture connections.
2. Dimensions: Full sash opening height is 28-inches, the total unobstructed viewing height is 37.5-inches measured from the work surface.
3. Sash Tracks: Steel with Chemical Resistant Finish. Shall include bump stops for opening and closing.
4. Sash Handle: extruded aluminum with Chemical Resistant Finish. Sash handle includes a perforated air passage directly atop the handle to bleed air into the hood chamber and direct chemical fumes away from the user's breathing zone. The handle is ergonomic in design and is easy to grasp when operating
5. Sash guides: Corrosion resistant extruded poly-vinyl chloride.
6. Sash System: Vertical Sash (Cable and Pulley)
 - a. Hoods have a single vertical sash counterbalanced by a single weight.
 - b. Sash and weight to be connected via aircraft cable meeting MIL-W-83420 Military Specification.
 - c. Rear pulleys shall be connected via timing shaft to prevent sash tilting and permit one finger operation at any point along full width sash handle. Maximum 7 pounds pull required to raise or lower sash throughout its full length of travel.
 - d. Design system to hold sash at any position without creep and to prevent sash drop in the event of cable failure.

- e. Include a defeatable, and automatically resetting sash stop positioned for an 18-inch sash height.

J. Electrical Components:

1. Lighting

- a. Provide UL Listed, high-efficiency, quick-start, LED lighting systems, including bulbs.

(1) 4 Foot Hoods - 2 each, 3-foot 11-watt LED lamps

- b. Vapor-Proof: all electrical components shall be outside of the contaminated air space. Lighting shall be located behind a laminated safety glass shield, sealed to the top of the hood liner.
- c. The LED light assemblies shall be serviceable from outside the fume hood cavity, without the use of tools.
- d. Light switch to be included on the lower right corner post, at heights compliant with the Americans with Disabilities Act (ADA).

2. Blower Switch: Hoods shall be provided with blower switch, on the lower right corner post, at heights compliant with the Americans with Disabilities Act (ADA).

3. Electrical Receptacles:

- a. The hoods shall accommodate up to four (two per corner post) electrical receptacles as indicted in schedule or drawings. Options to include:
- b. 115 volt, 60 Hz, three-wire polarized and grounded electrical duplex
- c. 115 volt, 60 Hz, three-wire polarized and grounded electrical duplex, with Ground Fault Circuit Interruption (GFCI)
- d. 230 volt, 60 Hz, three-wire polarized and grounded electrical duplex
- e. Receptacles shall be individually wired to field wiring box, and each rated at 20 Amperes.
- f. Cover plates shall be acid resistant thermoplastic.

4. Wiring:

- a. Every electrical component shall be individually wired to a single point internal field wiring box (including individual duplexes/receptacles).
- b. Field wiring box to be 7 x 4 x 2.5 inches, grounded, and have (12) 7/8-inch diameter knock out penetrations.

- c. Final wiring and circuit dedication is to be by others.
 - d. Each receptacle circuit shall accommodate being wired to a dedicated building circuit rated at 20A, or the receptacles wired to a single circuit with the total load not exceeding 20 Amperes.
- 5. Fume hood to have third party validation of compliance to UL 1805 and UL 61010-1 by a Nationally Recognized Testing Laboratory (NRTL)
- K. Upper Dilution Air Supply:
 - 1. Located behind and above the sash to introduce between 5 and 10% of the required hood air volume, and maintain sufficient exhaust air volume through hood to adequately dilute hazardous fumes regardless of sash position.
 - 2. This device bathes the sash interior above the work area to eliminate chemical fumes along the sash plane near the operator's critical breathing zone.
 - 3. Shall act as a by-pass opening controlled by sash position. If on a constant volume mechanical system, the hood shall not have a change in static pressure or exhaust volume across all sash positions.
 - 4. Shall offer a significant restriction to the by-pass opening to allow the use of a VAV mechanical system without modification to the by-pass opening.
- L. Hood Safety Practices Label: Corrosion resistant plate attached to the left corner post of the fume hood with the following Hood Safety Practices:
 - 1. For use with substances that produce hazardous levels of airborne chemicals: gas, fumes, vapors, dust
 - 2. Do not put your head in the hood.
 - 3. Minimize drafts and sudden movements in front of the hood.
 - 4. Work a minimum of six inches inside the hood.
 - 5. Elevate equipment above the work surface.
 - 6. Keep sill and baffle unobstructed.
 - 7. Do not use the hood for storage.
 - 8. Adjust the sash to smallest opening possible when in use.
 - 9. Close sash when unattended.
 - 10. Do not remove any of the hood components.

11. Do not place flammable solvents near heat, flame or sparks.
12. Do not evaporate large amounts of flammable liquids.
13. Wipe up spills immediately.
14. Routinely validate airflow.
15. If the ventilation system malfunctions, or airflow alarm indicates unsafe condition, close sash and discontinue hood operation immediately-call for help.
16. Do not use with Biohazards and Perchloric Acid

M. Fume Hood Accessories:

1. Tissue Screen: Provide epoxy-coated, stainless-steel screen at bottom baffle opening to prevent paper from being drawn into the exhaust plenum behind baffles.
2. Ceiling Enclosure Panels:
 - a. Provide filler panels matching fume hood exterior to enclose space above fume hoods at front and sides of fume hoods and extending from tops of fume hoods to ceiling.
 - b. Exposed fasteners are not acceptable.
 - c. Height adjustment to be within the following ranges as specified in the schedule.

(1) 14.0 – 18.6”
3. Distillation Grid: Include stainless steel rods, connectors, and factory drilled liner.

N. Work Surface:

1. 1.25-inches thick, molded from solid modified epoxy resin, with smooth, non-specular, black finish.
2. One inch radius front edge for optimal fume hood performance.
3. 3/8-inch dished area to match the fume hood interior work space and form a water tight pan for spill containment.
4. Include a 2.5-inch diameter hole on each side for service pass-through and piping. Hole to be covered by hood superstructure upon installation.
5. Include two 1.5” diameter penetrations to accommodate base cabinet venting. Holes to be located outside of dished area and under the fume hood baffles. Include plugs.

6. Physical Properties:

- a. Flexural Strength: Not less than 10,000 psi (70 MPa).
- b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
- c. Hardness (Rockwell M): Not less than 100.
- d. Water Absorption (24 Hours): Not more than 0.02 percent.
- e. Heat Distortion Point: Not less than 260 deg F (127 deg C).
- f. Flame-Spread Index: 25 or less per ASTM E 84.

O. Supporting Base Cabinets:

1. Construction requirements for cabinets:

- a. Exterior construction is minimum 18 gauge cold rolled sheet steel with Chemical Resistant Finish.
- b. Hinges are minimum 10 gauge plate with self-clinching pilot pin. Knuckle, bullet, or piano type hinges are not accepted.
- c. The rear panel will feature a 12-inches x 8-inches removable plumbing access panel.
- d. Units 24-inches wide or less have only one door.
- e. Each cabinet includes four leveling feet.
- f. Capable of supporting up to 800 pounds.

2. Acid Storage:

- a. Overall exterior dimensions: 48" w x 22" d x 35.5"-36.75"
- b. Completely lined with a polyethylene corrosion resistant liner. The liner is 3/16" thick, with a vacuum formed PVC liner pan at the bottom to contain spills. Each door has a 3/16" sheet polyethylene liner.
- c. The cabinet is labeled: "ACID".
- d. Flush pull handles are ABS, low gloss black.
- e. Each cabinet is vented into the fume hood with a 1 1/2" vent pipe. It should provide a positive airflow directly into the fume hood exhaust system.

- f. Supply an epoxy coated steel shelf with PVC liner pan if indicated in the schedule.
- g. Acid cabinets with louvers are not acceptable

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fume hoods.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Install fume hoods according to manufacturer's written instructions. Install level, plumb, and true; shim as required, using concealed shims, and securely anchor to building and adjacent laboratory casework. Securely attach access panels but provide for easy removal and secure reattachment. Where fume hoods abut other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.
- B. Comply with requirements for installing water and laboratory gas service fittings and electrical devices.
 - 1. Install fittings according to Shop Drawings, installation requirements in SEFA 2.3, and manufacturer's written instructions. Set bases and flanges of sink and work top-mounted fittings in sealant recommended by manufacturer of sink or work-top material. Securely anchor fittings to fume hoods unless otherwise indicated.

3.03 FIELD QUALITY CONTROL

- A. Field test installed fume hoods according to "Flow Visualization and Velocity Procedure" requirements in ASHRAE 110.
 - 1. Test installed fume hood, according to ASHRAE 110 as modified in "Performance Requirements" Article.
- B. Field test installed fume hood according to ASHRAE 110 as modified in "Performance Requirements" Article to verify compliance with performance requirements.
 - 1. Adjust fume hood, hood exhaust fans and building's HVAC system, or replace hood and make other corrections until tested hood performs as specified.
 - 2. After making corrections, retest fume hood.

3.04 ADJUSTING AND CLEANING

- A. Adjust moving parts for smooth, near silent, accurate sash operation with one hand. Adjust sashes for uniform contact of rubber bumpers. Verify that counterbalances operate without interference.
- B. Clean finished surfaces, including both sides of glass; touch up as required; and remove or refinish damaged or soiled areas to match original factory finish, as approved by Engineer.

END OF SECTION

SECTION 12 21 13
HORIZONTAL LOUVER BLINDS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Horizontal louver blinds, aluminum slats.

B. Related Requirements:

1. Section 06 10 00 "Rough Carpentry" for wood blocking and grounds for mounting horizontal louver blinds and accessories.

1.02 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Rated capacities, operating characteristics, and furnished accessories.

B. Shop Drawings: For horizontal louver blinds.

1. Fabrication and installation details.

C. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type and color of horizontal louver blind.

1. Include Samples of accessories involving color selection.

D. Samples for Verification: Actual sample of finished products for each type and color of horizontal louver blind.

1. Size: Manufacturers' standard size.

E. Product Schedule: For horizontal louver blinds. Use same designations indicated on Drawings.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For horizontal louver blinds.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver horizontal louver blinds in factory packages, marked with manufacturer, product name, and location of installation, using same designations indicated on Drawings.

1.05 FIELD CONDITIONS

- A. Environmental Limitations: Do not install horizontal louver blinds until construction and wet-work and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at levels indicated for Project when occupied for its intended use.
- B. Field Measurements: Where horizontal louver blinds are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Engineer of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1.06 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of motorized products that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of motorized operating system components.
 - 2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain horizontal louver blinds from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

- A. Window Covering Safety Standard: Provide horizontal louver blinds that comply with WCMA A100.1.

2.03 HORIZONTAL LOUVER BLINDS, ALUMINUM SLATS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Hunter Douglas Architectural Window Coverings.

2. Levolor Inc.
 3. Springs Window Fashions; SWF contract.
- B. Slats: Aluminum; alloy and temper recommended by producer for type of use and finish indicated; with crowned profile and radius corners.
1. Width: 1 inch (25 mm).
 2. Thickness: Not less than 0.008 inch (0.20 mm).
 3. Spacing: Manufacturer's standard.
 4. Finish: Ionized antistatic, dust-repellent, baked polyester finish.
- C. Ladders: Evenly spaced across headrail at spacing that prevents long-term slat sag.
1. Type: Braided cord.
- D. Headrail: Formed steel or extruded aluminum; long edges returned or rolled. Headrails fully enclose control mechanisms on three sides.
- E. Manual Corded Operation:
1. Lift Mechanism:
 - a. Lift-Cord Lock: Top locking; stops lift cord when blind is in fully opened or fully closed positions only; equipped with ring pull not more than 4 inches (100 mm) long.
 2. Lift Operator: Extension of inner lift cord(s) through lift-cord lock mechanism to form lift cord.
 3. Lift Cord: Manufacturer's standard braided cord.
 4. Lift-Cord Length: Short cord, not greater than 8 inches (203 mm) when blind is fully closed.
 5. Tilt Mechanism: Enclosed worm-gear mechanism and linkage rod that adjusts ladders.
 6. Tilt Operator: Corrosion-resistant steel rod.
 7. Tilt Over-Rotation Protection: Manufacturer's detachable operator or slip clutch to prevent over-rotation of gear.
 8. Tilt-Operator Length, Wand or Rod: Manufacturer's standard.

- F. Bottom Rail: Formed-steel or extruded-aluminum tube that secures and protects ends of ladders and inner lift cords and has plastic- or metal-capped ends.
- G. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.
 - 1. Intermediate Support: Provide intermediate support brackets to produce support spacing recommended by horizontal louver blind manufacturer for weight and size of blind.
- H. Colors, Textures, Patterns, and Gloss:
 - 1. Slats: As indicated on Drawings, or as selected by Engineer from manufacturer's full range.
 - 2. Components: Provide rails, cords, ladders, and materials exposed to view matching or coordinating with slat color unless otherwise indicated.

2.04 FABRICATION OF HORIZONTAL LOUVER BLINDS

- A. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):
 - 1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which blind is installed less 1/4 inch (6 mm) per side or 1/2 inch (13 mm) total, plus or minus 1/8 inch (3.1 mm). Length equal to head-to-sill dimension of opening in which blind is installed less 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm).
 - 2. Outside of Jamb Installation: Width and length as indicated, with terminations between blinds of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.
- B. Concealed Components: Noncorrodible or corrosion-resistant-coated materials.
 - 1. Lift-and-Tilt Mechanisms: With permanently lubricated moving parts.
- C. Mounting Brackets: Designed for removal and reinstallation of blind without damaging blind and adjacent surfaces, for supporting blind components, and for bracket positions and blind mounting method indicated.
- D. Installation Fasteners: No fewer than two fasteners per bracket, fabricated from metal noncorrosive to brackets and adjoining construction; type designed for securing to supporting substrate; and supporting blinds and accessories under conditions of normal use.

E. Color-Coated Finish:

1. Metal: For components exposed to view, unless anodized or plated finish is indicated, apply manufacturer's standard baked finish complying with manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF HORIZONTAL LOUVER BLINDS

- A. Install horizontal louver blinds level and plumb, aligned and centered on openings, and aligned with adjacent units in accordance with manufacturer's written instructions.
 1. Locate so exterior slat edges are not closer than 1 inch (25 mm) from interior faces of glass and not closer than 1/2 inch (13 mm) from interior faces of glazing frames through full operating ranges of blinds.
 2. Install mounting brackets to prevent deflection of headrails.
 3. Install with clearances that prevent interference with adjacent blinds, adjacent construction, and operating hardware of glazed openings, other window treatments, and similar building components and furnishings.
- B. Electrical Connections: Connect motorized operators to building electrical system.

3.03 ADJUSTING

- A. Adjust horizontal louver blinds to operate free of binding or malfunction through full operating ranges.

3.04 CLEANING AND PROTECTION

- A. Clean horizontal louver blind surfaces after installation in accordance with manufacturer's written instructions.
- B. Provide final protection and maintain conditions in a manner acceptable to manufacturer and Installer that ensures that horizontal louver blinds are without damage or deterioration at time of Substantial Completion.

- C. Replace damaged horizontal louver blinds that cannot be repaired in a manner approved by Engineer before time of Substantial Completion.

END OF SECTION

SECTION 12 35 53.13

METAL LABORATORY CASEWORK

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metal laboratory casework.
2. Auxiliary cabinets.
3. Countertops.
4. Laboratory casework systems.
5. Laboratory accessories.
6. Water and laboratory gas service fittings.
7. Electrical and communication service fittings.

B. Related Requirements:

1. Section 06 10 00 "Rough Carpentry" for wood blocking for anchoring laboratory casework.
2. Section 09 22 16 "Non-Structural Metal Framing" for reinforcements in metal-framed partitions for anchoring laboratory casework.
3. Section 09 65 13 "Resilient Base and Accessories" for resilient base applied to laboratory casework.
4. Section 11 53 13 "Laboratory Fume Hoods" for fume hoods, including base cabinets and countertops under fume hoods.

1.02 PREINSTALLATION MEETINGS

- ###### A. Preinstallation Conference: Conduct conference at Project site.

1.03 COORDINATION

- ###### A. Coordinate layout and installation of framing and reinforcements for support of laboratory casework.
- ###### B. Coordinate installation of laboratory casework with installation of laboratory equipment.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For laboratory casework.
 - 1. Include plans, elevations, sections, and attachments to other work including blocking and reinforcements required for installation.
 - 2. Indicate types and sizes of casework.
 - 3. Indicate manufacturer's catalog numbers for casework.
 - 4. Show fabrication details, including types and locations of hardware.
 - 5. Indicate locations and types of service fittings.
 - 6. Include details of utility spaces showing supports for conduits and piping.
 - 7. Include details of support framing system.
 - 8. Include details of exposed conduits, if required, for service fittings.
 - 9. Indicate locations of and clearances from adjacent walls, doors, windows, other building components, and laboratory equipment.
 - 10. Include coordinated dimensions for laboratory equipment specified in other Sections.
- C. Samples for Initial Selection: For casework finishes and materials requiring color selection.
- D. Samples for Verification: For each type of casework, exposed-hardware, and countertop-material finish, in manufacturer's standard sizes.
- E. Delegated Design Submittals: For laboratory casework indicated to comply with seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer.
- B. Product Test Reports:
 - 1. Casework: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating compliance of laboratory casework with requirements of specified product standard and system structural performance specified in "Performance Requirements" Article.

2. Countertop Surface Material: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating compliance of laboratory countertop surface material with requirements specified for chemical and physical resistance.

1.06 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish complete touchup kit for each type and color of casework finish provided. Include fillers, primers, paints, and other materials necessary to perform permanent repairs to damaged laboratory casework finish.

1.07 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer that produces casework of types indicated for this Project that has been tested for compliance with SEFA 8 M.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Protect finished surfaces during handling and installation with protective covering of polyethylene film or other suitable material.

1.09 FIELD CONDITIONS

- A. Environmental Limitations: Do not deliver or install laboratory casework until building is enclosed, utility roughing-in and wet-work are complete, and HVAC system is operating and maintaining temperature and relative humidity at levels planned for building occupants during the remainder of the construction period.
- B. Established Dimensions: Where laboratory casework is indicated to fit to other construction, establish dimensions for areas where casework is to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.
- C. Field Measurements: Where laboratory casework is indicated to fit to existing construction, verify dimensions of existing construction by field measurements before fabrication and indicate measurements on Shop Drawings. Provide fillers and scribes to allow for trimming and fitting.
- D. Locate concealed framing, blocking, and reinforcements that support casework by field measurements before enclosing them, and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain laboratory casework from single source from single manufacturer unless otherwise indicated.

- B. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer's catalog numbers. Other manufacturers' laboratory casework of similar sizes and similar door and drawer configurations and complying with Specifications may be considered. See Section 01 60 00 "Product Requirements."

2.02 PERFORMANCE REQUIREMENTS

- A. System Structural Performance: Laboratory casework and support framing system shall withstand the effects of the following gravity loads and stresses without permanent deformation, excessive deflection, or binding of drawers and doors:
 - 1. Support Framing System: 600 lb/ft. (900 kg/m).
 - 2. Suspended Base Cabinets (Internal Load): 160 lb/ft. (240 kg/m).
 - 3. Work Surfaces (Including Tops of Suspended Base Cabinets): 160 lb/ft. (240 kg/m).
 - 4. Wall Cabinets (Upper Cabinets): 160 lb/ft. (240 kg/m).
 - 5. Shelves: 40 lb/sq. ft. (200 kg/sq. m).
- B. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design laboratory casework installation.
- C. Seismic Performance: Laboratory casework installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. Design earthquake spectral response acceleration, short period (Sds) for Project is indicated on Drawings.
 - 2. Component Importance Factor: 1.0.
 - 3. Base Cabinet Load (Including Countertop and Load on Countertop): 320 lb/ft. (480 kg/m).
 - 4. Wall Cabinet (Upper Cabinet) Load: 160 lb/ft. (240 kg/m).

2.03 CASEWORK, GENERAL

- A. Casework Product Standard: Comply with SEFA 8 M, "Laboratory Grade Metal Casework."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.04 METAL LABORATORY CASEWORK

- A. Steel Sheet: Cold-rolled, commercial steel (CS) sheet, complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. CIF Laboratory Solutions.
 - 2. Hamilton Laboratory Solutions, LLC.
 - 3. Hanson Lab Solutions.
 - 4. ICI Scientific.
 - 5. Kewaunee Scientific Corporation.
 - 6. Mott Manufacturing Ltd.
- C. Nominal Metal Thickness:
 - 1. Sides, Ends, Fixed Backs, Bottoms, Tops, Soffits, and Items Not Otherwise Indicated: 0.048 inch (1.21 mm). Except for flammable liquid storage cabinets, bottoms may be 0.036 inch (0.91 mm) if reinforced.
 - 2. Back Panels, Doors, Drawer Fronts and Bodies, and Shelves: 0.036 inch (0.91 mm) except 0.048 inch (1.21 mm) for back panels and doors of flammable liquid storage cabinets and for unreinforced shelves more than 36 inches (900 mm) long.
 - 3. Intermediate Horizontal Rails, Table Aprons and Cross Rails, Center Posts, and Top Gussets: 0.060 inch (1.52 mm).
 - 4. Drawer Runners, Sink Supports, and Hinge Reinforcements: 0.075 inch (1.90 mm).
 - 5. Leveling and Corner Gussets: 0.105 inch (2.66 mm).

2.05 AUXILIARY CABINETS

- A. Tempered Glass for Glazed Doors: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

2.06 CABINET HARDWARE

- A. General: Provide laboratory casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.

- B. Hinges: Stainless-steel, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips. Provide two for doors 48 inches (1200 mm) high or less and three for doors more than 48 inches (1200 mm) high.
- C. Hinged-Door and Drawer Pulls: Stainless steel, back-mounted pulls. Provide two pulls for drawers more than 24 inches (600 mm) wide.
 - 1. Design: As selected from manufacturer's full range.
 - 2. Overall Size: 1 by 4-1/2 inches (25 by 114 mm).
- D. Door Catches: Nylon-roller spring or Dual, self-aligning, permanent magnet catches. Provide two catches on doors more than 48 inches (1200 mm) high.
- E. Drawer Slides: ANSI/BHMA A156.9.
 - 1. Heavy Duty (Grade 1HD-100): Side mount or Undermount.
 - a. Type: Full extension.
 - b. Material: Epoxy-coated polymer slides.
 - c. Motion Feature: Soft close dampener.
 - 2. General-purpose drawers; provide 100 lb (45 kg) load capacity.
- F. Locks: Cam or half-mortise type, brass with chrome-plated finish; complying with BHMA A156.11, Type E07281, Type E07261, Type E07111, or Type E07021.
 - 1. Tumbler: Disc.
 - 2. Lock Locations: Provide on drawers and doors.
 - 3. Keying: Key locks as directed by Owner.
 - 4. Key Quantity: Minimum of two keys per lock.
- G. Label Holders: Stainless steel, aluminum, or chrome plated; sized to receive standard label cards approximately 1 by 2 inches (25 by 50 mm), attached with screws or rivets. Provide on drawers.

2.07 COUNTERTOPS

- A. General: Provide laboratory countertops with integral sink as indicated on Drawings.
- B. Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, nonspecular finish.
 - 1. Physical Properties:

- a. Flexural Strength: Not less than 10,000 psi (70 MPa).
 - b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
 - c. Hardness (Rockwell M): Not less than 100.
 - d. Water Absorption (24 Hours): Not more than 0.02 percent.
 - e. Heat Distortion Point: Not less than 260 deg F (127 deg C).
2. Chemical Resistance: Epoxy-resin material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:
- a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
 - b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).
3. Color: As selected by Engineer from epoxy manufacturer's full range.
- C. Countertop Support Bracket:
- 1. Equal to Rakks Surface Mounter EH Counter Support Bracket
 - 2. Support brackets fabricated by welding miter cut extruded aluminum sections, grinding and deburring sharp edges and welds, drilling holes for field attachment, and factory finishing.
 - 3. Capacity: Up to 450 lbs/bracket.
 - 4. Material: Fabricate components from extruded aluminum sections complying with ASTM B221, 6063-T5 alloy and temper.
 - 5. Finish: Black Powder Coating

2.08 METAL CABINET FABRICATION

- A. General: Assemble and finish units at point of manufacture. Use precision dies for interchangeability of like-size drawers, doors, and similar parts. Perform assembly on precision jigs to provide units that are square. Reinforce units with angles, gussets, and channels. Except where otherwise specified, integrally frame and weld cabinet bodies to form dirt- and vermin-resistant enclosures. Where applicable, reinforce base cabinets for sink support. Maintain uniform clearance around door and drawer fronts of 1/16 to 3/32 inch (1.5 to 2.4 mm).

- B. Flush Doors: Outer and inner pans that nest into box formation, with full-height channel reinforcements at center of door. Fill doors with noncombustible, sound-deadening material.
- C. Glazed Doors: Hollow-metal stiles and rails of similar construction as flush doors, with glass held in resilient channels or gasket material.
- D. Hinged Doors: Mortise for hinges and reinforce with angles welded inside inner pans at hinge edge.
- E. Drawers: Fronts made from outer and inner pans that nest into box formation, without raw metal edges at top. Sides, back, and bottom fabricated in one piece with rolled or formed top of sides for stiffening and comfortable grasp for drawer removal. Provide drawers with rubber bumpers, polymer roller slides, and positive stops to prevent metal-to-metal contact or accidental removal.
- F. Adjustable Shelves: Front, back, and ends formed down, with edges returned horizontally at front and back to form reinforcing channels.
 - 1. Provide base cabinets with one adjustable shelf, and wall cabinets with 2 adjustable shelves.
- G. Toe Space: Fully enclosed, 4 inches (100 mm) high by 3 inches (75 mm) deep, with no open gaps or pockets.
- H. Utilities: Provide space, cutouts, and holes for pipes, conduits, and fittings in cabinet bodies to accommodate utility services and their support-strut assemblies.
 - 1. Provide base cabinets with removable backs for access to utility space.
- I. Filler and Closure Panels: Provide where indicated and as needed to close spaces between casework and walls, ceilings, and equipment. Fabricate from same material and with same finish as casework and with hemmed or flanged edges unless otherwise indicated.

2.09 LABORATORY CASEWORK SYSTEMS

- A. Provide casework manufacturer's standard integrated system that includes support framing, suspended modular cabinets, filler and closure panels, undercabinet task-lighting fixtures, countertops, and fittings needed to assemble system. System includes hardware and fasteners for securing support framing to permanent construction.
 - 1. Cabinets can be removed and reinstalled without use of special tools for relocation within system.
 - 2. Base cabinets can be removed without providing temporary support for, or removing, countertops.
 - 3. Sinks are supported independent of base cabinets.

4. System includes filler and closure panels to close spaces between support framing, cabinets, shelves, countertops, floors, and walls unless otherwise indicated. Fabricate panels from same material and with same finish as metal cabinets and with hemmed or flanged edges.

- B. Countertops: Provide in modular lengths indicated, without seams.

2.10 METAL CABINET FINISH

- A. General: Prepare, treat, and finish welded assemblies after assembling. Prepare, treat, and finish components that are to be assembled with mechanical fasteners before assembling. Prepare, treat, and finish concealed surfaces same as exposed surfaces.
- B. Preparation: After assembly, clean surfaces of mill scale, rust, oil, and other contaminants. After cleaning, apply a conversion coating suited to organic coating to be applied over it.
- C. Chemical-Resistant Finish: Immediately after cleaning and pretreating, apply laboratory casework manufacturer's standard two-coat, chemical-resistant, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).
 1. Chemical and Physical Resistance of Finish System: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8 M. Acceptance level for chemical spot test shall be no more than for Level 3 conditions.
 2. Colors for Metal Laboratory Casework Finish: As selected by Engineer from manufacturer's full range.

2.11 COUNTERTOP FABRICATION

- A. Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly beveled. Provide front and end overhang of 1 inch (25 mm).
- B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Engineer.
 1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2 (DN 40), unless otherwise indicated.
 2. Overflows: For each sink except cup sinks, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches (50 mm) less than sink depth. Provide in same material as strainer.
- C. Epoxy:

1. Countertops: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.
 - a. Marine-Edge Configuration: 5/8-inch (16-mm) minimum thickness, with integral or applied raised edge.
 - (1) Edges and Corners: Rounded.
 - (2) Backsplash: Integral coved.
 - b. Construction: Uniform throughout full thickness.
 - c. Product Option: Phenolic-composite countertops may be substituted for epoxy countertops at Contractor's option.
2. Sinks: Molded in one piece with smooth surfaces, coved corners, and bottom sloped to outlet; 1/2-inch (13-mm) minimum thickness.
 - a. Provide with polypropylene strainers and tailpieces.
 - b. Provide integral sinks in epoxy countertops, bonded to countertops with invisible joint line.
 - c. Provide sinks for drop-in installation in phenolic-composite countertops with 1/4-inch- (6-mm-) thick lip around perimeter of sink.
 - d. Provide sinks for underside installation with manufacturer's recommended adjustable support system for table- and cabinet-type installations.

D. Cup Sinks: Provide in material indicated, 5-inch (127-mm) diameter.

1. Epoxy Cup Sinks: Provide with polypropylene strainers and integral tailpieces.

2.12 LABORATORY ACCESSORIES

- A. Reagent Shelves: Provide as indicated, fabricated from same material as adjacent countertop unless otherwise indicated.
- B. Burette Rods: Aluminum or stainless steel rods, 1/2 inch (13 mm) in diameter and 18 inches (450 mm) long, threaded on one end to fit tapered plug adapter for flush socket receptacle. Provide with tapered plug adapter and receptacle.
- C. Lattice Assembly: Aluminum or stainless steel, vertical and horizontal rod lattice assembly with 3/4-inch- (19-mm-) diameter rods at approximately 12 inches (300 mm) o.c. with two flush socket receptacles for mounting.
- D. Resin Pegboards: Epoxy pegboards with removable polypropylene pegs and stainless steel drip troughs with drain outlet.

2.13 WATER AND LABORATORY GAS SERVICE FITTINGS

- A. Service Fittings: Provide units that comply with SEFA 7, "Recommended Practices for Fixtures." Provide fittings complete with washers, locknuts, nipples, and other installation accessories. Include wall and deck flanges, escutcheons, handle extension rods, and similar items.
- B. Materials: Fabricated from cast or forged red brass unless otherwise indicated.
 - 1. Reagent-Grade Water Service Fittings: Polypropylene, PVC, or PVDF for parts in contact with water.
- C. Finish: Chromium plated.
 - 1. Provide chemical-resistant powder coating in laboratory casework manufacturer's standard metallic brown, aluminum, white, or other color as approved by Engineer.
- D. Water Valves and Faucets: Provide units complying with ASME A112.18.1, with renewable seats, designed for working pressure up to 80 psig (550 kPa).
 - 1. Vacuum Breakers: Provide ASSE 1035 vacuum breakers on water fittings with serrated outlets.
 - 2. Aerators: Provide aerators on water fittings that do not have serrated outlets.
 - 3. Self-Closing Valves: Provide self-closing valves where indicated.
- E. Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by "L."
- F. Handles: Provide three- or four-arm, forged-brass handles for valves unless otherwise indicated.
 - 1. Provide lever-type handles for ground-key cocks. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.

2.14 ELECTRICAL AND COMMUNICATION SERVICE FITTINGS

- A. Service Fittings, General: Provide units complete with metal housings, receptacles, switches, pilot lights, data communication outlets, cover plates, accessories, and gaskets required for mounting on laboratory casework.
- B. Electrical Wiring Devices: Comply with requirements in Section 26 27 26 "Wiring Devices" for receptacles, switches, pilot lights, cover plates, and accessories.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances, location of reinforcements, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF CABINETS

- A. Comply with installation requirements in SEFA 2. Install level, plumb, and true in line; shim as required using concealed shims. Where laboratory casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical. Do not exceed the following tolerances:
 - 1. Variation of Tops of Base Cabinets from Level: 1/16 inch in 10 feet (1.5 mm in 3 m).
 - 2. Variation of Bottoms of Upper Cabinets from Level: 1/8 inch in 10 feet (3 mm in 3 m).
 - 3. Variation of Faces of Casework from a True Plane: 1/8 inch in 10 feet (3 mm in 3 m).
 - 4. Variation of Adjacent Surfaces from a True Plane (Lippage): 1/32 inch (0.8 mm).
 - 5. Variation in Alignment of Adjacent Door and Drawer Edges: 1/16 inch (1.5 mm).
- B. Base Cabinets: Fasten cabinets to utility-space framing, partition framing, wood blocking, or reinforcements in partitions, with fasteners spaced not more than 16 inches (400 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.
 - 1. Where base cabinets are installed away from walls, fasten to floor at toe space at not more than 24 inches (600 mm) o.c. and at sides of cabinets with not less than two fasteners per side.
- C. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through back, near top, at not less than 16 inches (400 mm) o.c.
- D. Install hardware uniformly and precisely.
- E. Adjust operating hardware so doors and drawers align and operate smoothly without warp or bind and contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

3.03 INSTALLATION OF COUNTERTOPS

- A. Comply with installation requirements in SEFA 2. Abut top and edge surfaces true in plane with flush hairline joints and with internal supports placed to prevent deflection. Locate joints where indicated on Shop Drawings.
- B. Field Jointing: Where possible, make in same manner as shop-made joints, using dowels, splines, fasteners, adhesives, and sealants recommended by manufacturer. Shop prepare edges for field-made joints.
- C. Fastening:
 - 1. Secure epoxy countertops to cabinets with epoxy cement, applied at each corner and along perimeter edges at not more than 48 inches (1200 mm) o.c.
- D. Provide holes and cutouts required for service fittings.
- E. Provide scribe moldings for closures at junctures of countertop, curb, and splash with walls as recommended by manufacturer for materials involved. Match materials and finish to adjacent laboratory casework. Use chemical-resistant, permanently elastic sealing compound where recommended by manufacturer.
- F. Dress joints smooth, remove surface scratches, and clean entire surface.

3.04 INSTALLATION OF SINKS

- A. Comply with installation requirements in SEFA 2.

3.05 INSTALLATION OF LABORATORY ACCESSORIES

- A. Install accessories in accordance with Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions.
- B. Securely fasten adjustable shelving supports, stainless steel shelves, and pegboards to partition framing, wood blocking, or reinforcements in partitions.
- C. Install shelf standards plumb and at heights to align shelf brackets for level shelves. Install shelving level and straight, closely fitted to other work where indicated.
- D. Securely fasten pegboards to partition framing, wood blocking, or reinforcements in partitions.

3.06 INSTALLATION OF SERVICE FITTINGS

- A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.
- B. Install fittings in accordance with Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-

mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

3.07 CLEANING AND PROTECTING

- A. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Engineer.
- B. Protect countertop surfaces during construction with 6-mil (0.15-mm) plastic or other suitable water-resistant covering. Tape to underside of countertop at a minimum of 48 inches (1200 mm) o.c.

END OF SECTION

SECTION 12 36 61.16

SOLID SURFACING COUNTERTOPS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Solid surface material countertops.
 - 2. Solid surface material backsplashes.
 - 3. Solid surface window stools.

1.02 ACTION SUBMITTALS

- A. Product Data: For solid surface materials.
- B. Shop Drawings: Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.
 - 1. Show locations and details of joints.
 - 2. Show direction of directional pattern, if any.
- C. Samples for Initial Selection: For each type of material exposed to view.
- D. Samples for Verification: For the following products:
 - 1. Solid surface material, 6 inches (150 mm) square.

1.03 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For fabricator.

1.04 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For solid surface materials to include in maintenance manuals. Include Product Data for care products used or recommended by Installer and names, addresses, and telephone numbers of local sources for products.

1.05 QUALITY ASSURANCE

- A. Fabricator Qualifications: Shop that employs skilled workers who custom-fabricate countertops similar to that required for this Project, and whose products have a record of successful in-service performance.

- B. Installer Qualifications: Fabricator of countertops.

1.06 FIELD CONDITIONS

- A. Field Measurements: Verify dimensions of countertops by field measurements before countertop fabrication is complete.

1.07 COORDINATION

- A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.01 SOLID SURFACE COUNTERTOP MATERIALS

- A. Solid Surface Material: Homogeneous-filled plastic resin complying with ISFA 2-01.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Avonite Surfaces.
 - b. Du Pont Company.
 - c. Formica Corporation.
 - d. Wilsonart LLC.
 - 2. Type: Provide Standard type unless Special Purpose type is indicated.
 - 3. Colors and Patterns: Refer to Drawings.

2.02 FABRICATION

- A. Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."
 - 1. Grade: Custom.
- B. Configuration:
 - 1. Front: Straight, slightly eased at top.
 - 2. Backsplash: Straight, slightly eased at corner.

- C. Countertops: 1/2-inch- (12.7-mm-) thick, solid surface material with front edge built up with same material.
- D. Backsplashes: 1/2-inch- (12.7-mm-) thick, solid surface material.
- E. Window Stools: 1/2-inch- (12.7-mm-) thick, solid surface material, eased edge.
- F. Fabricate tops with shop-applied edges unless otherwise indicated. Comply with solid surface material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
 - 1. Fabricate with loose backsplashes for field assembly.
- G. Joints: Fabricate countertops without joints.
 - 1. If joints are required, minimize joint locations as much as possible.
 - a. Joint Locations: Not within 18 inches (450 mm) of a sink and not where a countertop section less than 36 inches (900 mm) long would result
 - 2. Plan material cuts in advance so that joints will appear seamless. Match material color, tone, and pattern across joints.
- H. Cutouts and Holes:
 - 1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.
 - 2. Counter-Mounted Plumbing Fixtures: Prepare countertops in shop for field cutting openings for counter-mounted fixtures. Mark tops for cutouts and drill holes at corners of cutout locations. Make corner holes of largest radius practical.
 - 3. Fittings: Drill countertops in shop for plumbing fittings, undercounter soap dispensers, and similar items.

2.03 INSTALLATION MATERIALS

- A. Adhesive: Product recommended by solid surface material manufacturer.
- B. Sealant for Countertops: Comply with applicable requirements in Section 07 92 00 "Joint Sealants."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates to receive solid surface material countertops and conditions under which countertops will be installed, with Installer present, for compliance with

requirements for installation tolerances and other conditions affecting performance of countertops.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install countertops level to a tolerance of 1/8 inch in 8 feet (3 mm in 2.4 m), 1/4 inch (6 mm) maximum. Do not exceed 1/64-inch (0.4-mm) difference between planes of adjacent units.
- B. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
- C. Install backsplashes and end splashes by adhering to wall and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears.
- D. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.
- E. Apply sealant to gaps at walls; comply with Section 07 92 00 "Joint Sealants."

END OF SECTION

SECTION 21 10 00
FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide fire protection systems as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.4: Gray Iron Threaded Fittings Classes 125 and 250.
- B. ASTM International (ASTM):
 - 1. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 2. A135/A135M: Standard Specification for Electric-Resistance-Welded Steel Pipe
 - 3. A234: Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
 - 4. A795: Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
- C. American Water Works Association (AWWA):
 - 1. C509: Resilient-Seated Gate Valves for Water Supply Service
- D. Canadian Industrial Risk Insurers (CIRI).
- E. Canadian Standards Association (CSA):
 - 1. B64: Backflow Preventers and Vacuum Breakers
 - 2. B137.2: PVC Injection-Moulded Gasketed Fittings for Pressure Applications
 - 3. B137.3: Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications
- F. FM Global (FM):
 - 1. Data Sheet 2-2: Installation Rules for Suppression-Mode Automatic Sprinklers.

2. Data Sheet 2-8: Earthquake Protection for Water-Based Fire Protection Systems.

G. Factory Mutual Engineering Association (FMEA).

H. National Fire Protection Association (NFPA):

1. 13: Standard for the Installation of Sprinkler Systems

2. 14: Standard for the Installation of Standpipe and Hose Systems

3. 20: Standard for the Installation of Stationary Pumps for Fire Protection

I. International Building Code 2018

J. International Fire Code 2018

1.03 DESIGN REQUIREMENTS:

A. Fire protection work is to be designed by an accredited fire protection company.

B. Fire protection system work is to be designed in accordance with NFPA and Provincial Codes, and where required, local building and fire department requirements and the standards of the Owner's Insurer.

C. Provide all additional working drawings and/or load calculations required and submit with shop drawings.

D. Water Supply: Conduct Municipal main water flow and pressure tests at the nearest fire hydrant to obtain criteria to be used in fire protection system design. Include hydrant location and flow and pressure test data with system design calculations.

E. Sprinkler System Occupancy – Hazard Design Requirements: The following NFPA 13 occupancy – hazard density requirements are, unless otherwise specified, to be adhered to when designing the sprinkler work:

1. Ordinary Hazard Group 1 Occupancies to be designed for 6.1 L/min./m² (0.15 usgpm/square feet) density over the hydraulically most remote 139.4 m² (1500 square feet) plus 15.77 L/s (250 usgpm) for fire hose allowance, to be used for the following areas:

a. LOWER LEVEL 001

b. PROCESS ROOMS 123-127

2. ESFR Areas: Size the pipe by hydraulic calculation to meet at least the minimum pressure requirements with the minimum number of sprinklers flowing. Use a sprinkler discharge coefficient (k-factor) of 14.0. Design all systems to supply the minimum needed sprinkler discharge pressure from the most hydraulically remote twelve sprinklers, flowing four sprinklers on three branch lines. When branch lines

contain less than four sprinklers, flow whole branch lines and any needed additional sprinklers on an adjacent branch line to achieve a 12-sprinkler total. With this design, it is unnecessary to limit flow velocity in overhead sprinkler piping. Also, when additional sprinklers are installed beneath obstructions, conveyors, or walkways, include all such sprinklers located within the design areas in the total water demand. Add hose demand to sprinkler demand at the point of connection. Use for the following areas:

- a. LOWER LEVEL 001
- b. PROCESS ROOMS 123-127

- 3. Sprinkler Head Locations: Sprinkler head locations must be carefully coordinated with all Drawings, including architectural reflected ceiling plan Drawings, where applicable, electrical Drawings, and process Drawings. Unless otherwise approved, the location and arrangement of "head end" equipment is to remain generally as shown, and final layout is to maximize space within the area while facilitating proper access to equipment. Maintain clearance at the front of electrical panels in accordance with Hydro One Inc. and Ontario Electrical Safety Code requirements, and locate all piping so as not to restrict access or movement in the room housing the head end equipment.

- F. Standpipe System Design Criteria: All standpipe system piping is to be hydraulically sized.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Shop Drawings: Submit fire protection system shop drawings to the regulatory authority for review and approval prior to submitting to the Consultant. Conform to the following requirements:
 - 1. Submit shop drawings for all products specified in this Section except pipe and fittings.
 - 2. Submit complete fire protection systems layout drawings indicating source of water supply, "head end" equipment piping schematic, pipe routing and sizing, and zones, all signed and sealed by a qualified professional mechanical engineer registered/licensed in the Utah.
 - 3. Submit copies of all Seismic and Hydraulic calculations signed by the same engineer who signs the layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing. Provide calculations to both Mechanical Engineer on the project and FM Global representative at least two weeks prior to construction.

4. In addition to submitting shop drawings to the regulatory authority as specified above, shop drawings must be approved by the Owner's insurer prior to being submitted to the Consultant for review.

C. Test Data: Submit the following test data prior to application for substantial performance:

1. Pipe leakage test sheets and test data as specified in Part 3 of this Section.
2. A copy of a certification letter from the fire pump set supplier in accordance with Part 3 of this Section.

D. Certificates: Submit certificates and documentation specified in this Section.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sprinkler work is to be performed by a sprinkler company who is a member in good standing of the Canadian Automatic Sprinkler Association.
- C. All site personnel are to be under the continuous supervision of a foreman who is an experienced fire protection system installer and a journeyman pipefitter.
- D. Check and verify all dimensions and conditions at the site and ensure that the Work can be performed as indicated.
- E. Coordinate fire protection Work with all trades at the site and accept responsibility for and the cost of making adjustments to piping and or spacing to avoid interference with other building components.
- F. Verify the working condition of all existing fire protection equipment which has direct interface with the new Work and is to remain. Replace with new equipment where necessary.
- G. All system components must be ULC listed and labelled.
- H. Manufacturer of valves, sprinklers and related components shall provide a limited warranty of ten (10) years against defects in materials and workmanship.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PIPE, FITTINGS AND JOINTS:

- A. PVC: Ipex "Brute Brute" Class 200, DR14, rigid, hub and spigot pattern PVC pipe and CSA certified fittings to CSA B137.2 and B137.3, ULC listed and FM approved and complete with gasketed joints.
- B. Schedule 40 Steel - Grooved Coupling Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with mill or site roll grooved ends, and Victaulic "Fire Lock" or "FIT Style 960 fittings", Gruvlock Fig. #7105 "Sock-It" fittings, Tyco Fire Suppression & Building Products Mechanical Outlet Tee Fig. 730 and Victaulic Style 005, Tyco Fire Suppression & Building Products #772, Gruvlok Rigid-Lite #7400, Shurjoint "Speed" or "Z05" rigid coupling joints or approved equivalent. Snap-Let type or strap type fittings are not acceptable.
- C. Schedule 40 Steel - Screwed and Welded Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping is to be complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping is to be complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible.
- D. Schedule 10 Steel - Grooved Coupling Joints: Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with mill or site roll grooved ends, and Victaulic "Fire Lock" fittings, Tyco Fire Suppression & Building Products grooved fittings and Victaulic Style 005, Tyco Fire Suppression & Building Products #772, Gruvlok Rigid-Lite #7400 rigid coupling joints or approved equivalent. Snap-Let type or strap type fittings are not acceptable.
- E. Schedule 10 Steel - Screwed Joints: Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with mill or site threaded ends, Class 125 cast iron screwed fittings to ANSI/ASME B16.4, and screwed joints.
- F. "Lightwall" Steel - Grooved Coupling Joints: Allied "XL" commercial quality rolled mild carbon steel pipe to ASTM A135, Grade A, ULC listed, complete with a galvanized exterior, factory or site roll grooved ends, and Victaulic "Fire Lock" or Tyco Fire Suppression & Building Products grooved fittings and Victaulic Style 005, Tyco Fire Suppression & Building Products #772, Gruvlok Rigid-Lite #7400 rigid coupling joints or approved equivalent.
- G. "Lightwall" Steel-Screwed Joints: Allied "XL" commercial quality rolled mild carbon steel pipe to ASTM A135, Grade A, ULC listed, mill or site threaded, complete with galvanized exterior, Class 125 cast iron screwed fittings to ANSI/ASME B16.4, and screwed joints or approved equivalent.
- H. Schedule 5 Steel - Victaulic "Pressfit" Joints: Schedule 5 mild black carbon steel, ASTM A135, ASTM A795 or ASTM A53, complete with Victaulic "Pressfit" system synthetic rubber O-ring sealed 2005 kPa (175 psi) rated rigid carbon steel fittings and

Style 505 couplings for indented groove installation by means of a portable 115 volt plug-in electric tool.

2.02 INDICATOR POST VALVES AND INDICATOR POSTS:

- A. Valve: Cast iron, bronze trim, resilient seat, OS&Y gate valve with non-rising stem in accordance with AWWA C509, minimum 1380 kPa (200 psi) cold water rated and complete with a square operating nut and ends to suit connecting piping. Acceptable products are:

1. Mueller Co. ULC-FM resilient seat gate valve
2. Clow Canada Inc. Fig. No. F-6120
3. Nibco Series 609 RW

2.03 SERVICE MAIN DOUBLE CHECK VALVE ASSEMBLY:

- A. Minimum 2005 kPa (175 psi) rated, ULC listed and FM approved dual check valve backflow preventer assembly (less shut-off valves) to CAN/CSA B64, complete with test cocks. Acceptable products are:

1. Watts Regulator #709LF
2. Zurn/Wilkins #375 Series
3. Combraco 40-200 Series

2.04 SERVICE MAIN DOUBLE DETECTOR CHECK VALVE ASSEMBLY:

- A. Minimum 2005 kPa (175 psi) rated, ULC listed and FM approved dual check valve backflow preventer assembly (less shut-off valves) to CAN/CSA B64, complete with test cocks, and piping by-pass assembly with water meter. Acceptable products are:

1. Watts Regulator Series 07F with additional check valve
2. Zurn/Wilkins #375 Series
3. Combraco 40-600 Series

2.05 SHUT-OFF VALVES:

- A. Minimum 1205 kPa (175 psi) rated ULC listed and FM approved lug body or grooved end type ball or butterfly valves. Acceptable products are:

1. National Fire Equipment/GEC Alsthom butterfly type

2. Victaulic Series 728 "FireLock" ball type. (All Victaulic Firelock butterfly valves are not acceptable including, but not limited to Series 7A2, 7B2, 707C, 702, 705, 705W, 766, and 765.)
3. Tyco Fire Suppression & Building Products model BFV-N
4. Tyco Fire Suppression & Building Products Butterfly valve "Butterball" Model BB-SCS01
5. Anvil International Fig. AN-7722-3A
6. Nibco Fig #3510-8, Fig #GD-4765
7. Gruvlok Fig. AN-7722-3A
8. Global Safety Products Model BV
9. Kennedy Valve Co. #01G
10. Shurjoint #SJ-700W

2.06 CHECK VALVES:

- A. Minimum 1205 kPa (175 psi) rated, resilient seat, ULC listed and FM approved check valves. Acceptable products are:
 1. Victaulic "VIC-CHECK" Series 717/716
 2. Tyco Fire Suppression & Building Products Model CV-1F
 3. Tyco Fire Suppression & Building Products Model CV-1FR Riser Check Valve
 4. Nibco #F-908-W, G-917-W, KW-900-W, KT-403-W or T-480
 5. Kennedy Valve Co. #426
 6. Shurjoint #RCV
- B. Check valves associated with fire department connection(s) and fire pump test connection are to be tapped for site installation of a 20 mm (3/4-inch) diameter ball drip.

2.07 BALL DRIPS:

- A. A. National Fire Equipment Ltd. Model #58-2, Nibco Model #RG 22100, Tyco Fire Suppression & Building Products Model F789, 20 mm (3/4-inch) diameter automatic ball drip or approved equivalent.

2.08 SHUT-OFF VALVE SUPERVISORY SWITCHES:

- A. ULC listed and FM approved, tamper-proof, 24 volt or 115 volt AC supervisory switches, each arranged to activate a fire alarm trouble alarm condition if the valve is closed or tampered with, and with each complete with all required mounting and connection hardware. Acceptable products are:
 - 1. Potter Electric Signal and Manufacturing Ltd. Model "OSYSU" or "PCVS"
 - 2. System Sensor #P1BV2 or OSY2
 - 3. Victaulic Style 737

2.09 FIRE DEPARTMENT CONNECTION:

- A. Wall mounting polished brass Storz type connection with 6 inch diameter inlets threaded to Fire Department hose requirements and equipped with snoots, swivels, caps and chains, an outlet sized as shown, and a faceplate.
- B. The faceplate is to be complete with "AUTO-SPKR" cast-in raised lettering.
- C. All exposed metal parts of the fire department connection are to be chrome plated.
- D. Acceptable Manufacturers:
 - 1. American Fire Supply Model #SZ6
 - 2. Crocker #6350

2.10 FIRE PROTECTION MAIN "LOSS OF PRESSURE" ALARM SENSOR:

- A. ULC listed piping mounted adjustable pressure sensor designed to actuate an alarm upon sensing a loss of pressure in the fire protection main. The switch is to be low voltage or line voltage as required. Acceptable products are:
 - 1. Potter Electric Signal & Manufacturing Ltd. Model PS10-1A or 2A as required
 - 2. The Viking Corp #09470

2.11 WATER FLOW ALARM SWITCH:

- A. Pipe mounting water flow alarm switch, minimum 1725 kPa (250 psi) rated, designed to actuate two 7 ampere rated (at 125/250 VAC) SPDT snap action switches when water flow exceeds 0.758 L/second (10 gpm), complete with a tamper-proof cover with conduit connection opening, a piping saddle and U-bolt, and an automatic reset pneumatic retard device with field adjustable (0 to 70 second) switch actuation delay to reduce false alarms caused by a single or series of transient water flow surges. Acceptable products are:

1. The Viking Corp. Model VSR-F
2. System Sensor Model 10/40
3. Potter Electric Signal & Mfg. Model VSR-F
4. Victaulic Style 736

2.12 SPRINKLER SYSTEM ALARM CHECK VALVE:

- A. Enameled cast iron check valve assembly designed for either vertical or horizontal mounting and to actuate alarms when the wet type sprinkler system is activated. The assembly is to be minimum 2005 kPa (175 psi) cold water rated with all moving parts constructed of brass, bronze, stainless steel or EPDM, and is to be complete with:

1. A flanged inlet, and a flanged or grooved outlet as required.
2. Pipe fittings and accessories for site connection of an excess pressure pump.
3. Basic trim including piping materials and check valve for an external by-pass, potable water supply and system water supply pressure gauges with gauge test ports and shut-off valves, an angle type main drain valve, and fittings for mounting an alarm test by-pass.
4. Alarm test by-pass piping with ball valve to permit alarm testing without operation of the alarm valve.
5. Alarm trim with pipe and fittings for connection to a water motor alarm, and an adjustable pressure switch for electrical connection to an alarm system upon flow through the valve.

- B. Acceptable products (with specified trim and accessories) are:

1. The Viking Corp. Model J-1
2. Tyco Fire Suppression & Building Products Model AV-1-300
3. Reliable (Vipond Fire Protection) Model E
4. Victaulic Series 751 with trim

2.13 SPRINKLER ZONE FLOW ALARM AND INSPECTOR'S TEST VALVE ASSEMBLIES:

- A. Factory assembled sprinkler zone flow alarm switch, test and drain valve, sight glass, and pressure gauge. Acceptable products are:

1. Tyco Fire Suppression & Building Products F350 Series

2. Victaulic Style 720 "Test Master" with pressure gauge and Style 736 water flow alarm switch

2.14 SPRINKLER ZONE FLOW ALARM AND INSPECTOR'S TEST VALVE CABINETS:

- A. Flush wall mounting steel cabinets, each sized to contain a flow alarm switch, inspector's test valve with sight glass, pressure gauge, and associated piping, and complete with a hinged door with keyed lock, full length semi-concealed stainless steel piano hinge, adjustable trim, and "SPRINKLER ZONE ALARM & INSPECTOR'S TEST" permanent identification wording on the door.
- B. The interior of each cabinet and the backside of the door are to be factory finished in white enamel. The face of the door and the trim is to be prime coat painted.

2.15 SPRINKLER HEADS:

- A. Provide ULC listed heads as presented in Schedule 21 10 00-1.
- B. Sprinkler heads in finished areas are to be chrome plated unless otherwise specified.
- C. Where exposed pendent heads occurs in areas with suspended ceilings, they are to be complete with chrome plated escutcheon plates. Similarly, sidewall heads with concealed piping are to be complete with chrome plated escutcheon plates.
- D. Sprinkler heads which are exposed in areas where they may be subject to damage are to be complete with wire guards, chrome plated where in finished areas.
- E. Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 74 degrees C (165 degrees F) heads. All other heads, unless otherwise specified or required, are to be 57 degrees C (135 degrees F) rated.

2.16 SPARE SPRINKLER HEAD CABINET:

- A. Surface wall mounting, red enameled steel, identified cabinet with hinged door, shelves with holes for mounting sprinkler heads, a wrench or wrenches suitable for each type of sprinkler head, and a full complement of spare sprinkler heads.
- B. The cabinet is to be sized to accommodate a minimum of four spare heads for each type of head used on the Project, however, each cabinet is to be full of spare heads.

2.17 FIRE HOSE CABINETS:

- A. National Fire Equipment Ltd. ULC listed and FM approved fire hose cabinet assemblies, each complete:

1. A Model A-156, 40 mm (1-1/2 inch) forged brass, adjustable, pressure restricting angle hose valve.
 2. A Model A-156, 65 mm (2-1/2 inch) forged brass, adjustable, pressure restricting, Fire Department angle hose connection valve with cap and chain.
 3. A Model A-7-B 40 mm (1-1/2 inch) forged brass combination nozzle adjustable for fog, straight stream and shut-off.
 4. 30 m (100 feet) of 40 mm (1-1/2 inch) diameter "Polyfex" hose with Model F-4 forged brass couplings, a Model S-4 stationary hose rack with independently swiveling pins, and a Model S-5 automatic water stop.
 5. A Model C-21 "Trinal" spanner wrench.
 6. A Model ABC-050 HW, multipurpose, 3A:10BC rated dry chemical fire extinguisher.
- B. Recessed cabinets are to be "Knight" Series 200 mm (8 inch) deep cabinets complete with:
1. A 1.27 mm thick (18 gge) cold rolled steel tub with universal knockouts and a white enamel finish.
 2. A 1.98 mm thick (14 gge) steel door and adjustable trim assembly with rounded corner, full length semi-concealed piano hinge, prime coat finish, full panel of 6 mm (1/4-inch) thick "Duo-Lite" safety glass, and a flush stainless steel door latch.
- C. Surface mounted cabinets are to be Model C5-800 cabinets, each 200 mm deep and complete with:
1. A 1.27 mm thick (18 gge) cold rolled steel tube with universal knockouts and a white enamel interior finish and prime coated exterior.
 2. A 1.98 mm thick (14 gge) steel door with full length semi-concealed piano hinge, white enamel inside finish, primer coat exterior finish, full panel of 6 mm (1/4-inch) "Duo-Lite" safety glass, and a flush stainless steel door latch.
- D. All brass items in recessed cabinets are to be polished and chrome plated.
- E. Acceptable manufacturers are:
1. National Fire Equipment Limited
 2. Wilson & Cousins

PART 3 - EXECUTION

3.01 SPRINKLER SYSTEM PIPING INSTALLATION REQUIREMENTS:

- A. Perform all required sprinkler system Work.
- B. All pipe sizes, sprinkler head locations, head quantity, and layout of Work shown on the Consultants' Drawings are to assist you during the tendering period. Ensure adequate head coverage, head quantities and pipe sizing as specified in Part 1 of this Section. Do not reduce the size of the sprinkler main or re-route the main unless approved.
- C. Do all piping work in accordance with requirements of NFPA No. 13, "INSTALLATION OF SPRINKLER SYSTEMS", Provo Utah Regulations, and "reviewed" shop drawings.
- D. Pipe, unless otherwise specified, is to be as follows:
 - 1. For underground pipe inside or outside the building - Ipex "Blue Brute" Class 200, DR14 rigid PVC, braced and secured at bends and tees with concrete blocks in accordance with Municipal standards and details, and complete with No. 14 gge solid copper plastic insulated wire secured to the top of the pipe for the entire length of the pipe fastened with plastic type ties for pipe location tracing purposes. Lay pipes true to line and grade with bells up/grade. Fit sections together so that, when complete, the pipe has a smooth and uniform invert. Keep pipe thoroughly clean so that jointed compound will adhere. Inspect the pipe for defects before being lowered into the trench. Do not use defective pipe. All non-ferrous piping shall be changed to ferrous piping prior to entering the building using an Ebaa Iron Inc. Mega-Coupling Series 3800 or equivalent (i.e., changed before passing through basement floor or slab on grade).
 - 2. For piping inside building and above ground from service connection to discharge side of alarm valve, etc. - Schedule 40 grooved end black steel with Victaulic fittings and coupling joints, or, for piping to and including 50 mm (2 inch) diameter, screwed fittings and joints or piping 65 mm (2-1/2 inch) diameter and larger, welding fittings and welded joints.
 - 3. For pipe inside building and above ground to exterior pump test hose valve header and for fire department connection - Schedule 40 black steel as above.
 - 4. For piping downstream of "head end" alarm valve(s) and equipment – Schedule 10 or "Lightwall" black steel pipe with Victaulic fittings and coupling joints or screwed fittings and joints, or Schedule 5 black steel pipe with Victaulic "Pressfit" System fittings and coupling joints.
- E. Slope all horizontal piping so that it drains completely through risers, equipment, or through valved drainage branches. Provide capped hose end drain valves at all low points.

- F. Provide piping flushing connections consisting of threaded and capped 32 mm (1-1/4 inch) diameter, 100 mm (4 inch) long nipples on the end of mains where required.
- G. Provide non-freeze, glycol-water solution filled sprinkler piping where shown. Install the piping, complete with a CSA certified reduced pressure backflow preventer, valves and glycol solution fill facilities in accordance with requirements of Chapter 3 of NFPA 13. Fill the piping with a solution of 50 percent Union Carbide Canada Ltd. "UCAR THERMO-FLUID 17" or Dow Chemical Co. "Dowtherm SR1" or approved equivalent propylene glycol with corrosion inhibitors, and 50 percent clean water. Prior to filling the piping, check the specific gravity of the solution using a hydrometer with proper scale. Specific gravity is to be approximately 1.069 at 15.6 degrees C.
- H. When sprinkler work is complete, test system components and the overall system(s) and submit completed test certificate and other documentation in accordance with Chapter 14 of NFPA No. 13.

3.02 INSTALLATION OF DOUBLE CHECK VALVE ASSEMBLY:

- A. Provide a double check valve assembly in the sprinkler/standpipe main inside the building where shown.
- B. Equip the assembly with inlet and outlet supervised shut-off valves.
- C. Support each end of the assembly from the floor by means of flanged pipe supports with saddles.

3.03 INSTALLATION OF DETECTOR CHECK VALVE ASSEMBLY:

- A. Provide a detector check valve with water meter and connecting piping in the sprinkler main where shown. Confirm exact location prior to installation.
- B. Equip the assembly with inlet and outlet supervised shut-off valves.
- C. Support each end of the assembly from the floor by means of a flanged pipe support with saddles.

3.04 INSTALLATION OF SHUT-OFF VALVES AND CHECK VALVES:

- A. Provide shut-off valves and check valves in piping where shown.
- B. Locate all valves for easy operation and maintenance.
- C. Confirm exact locations prior to roughing-in.

3.05 INSTALLATION OF SHUT-OFF VALVE SUPERVISORY SWITCHES:

- A. Unless otherwise specified, equip each shut-off valve with a supervisory switch.

- B. Identify each supervised valve with a 150 mm (6 inch) square engraved laminated red-white plastic tag to correspond with supervised valve numbering specified and/or shown as part of the electrical work fire alarm system.

3.06 INSTALLATION OF FIRE DEPARTMENT CONNECTION:

- A. Provide a fire department connection for the fire protection system where shown. Confirm exact location prior to rough-in. Confirm finish prior to ordering.
- B. Equip the fire department connection with a check valve. Equip the check valve with a ball drip to drain the piping between the fire department connection and the check valve, and extend drainage piping from the outlet of the ball drip to the nearest suitable floor drain.

3.07 INSTALLATION OF "LOSS OF PRESSURE" SENSOR:

- A. Supply and mount a pressure sensor in the fire protection piping main to activate a "LOSS OF PRESSURE" trouble alarm should Municipal water service pressure fall below the acceptable level.
- B. Locate the sensor for easy access and maintenance, and set the alarm pressure to suit site conditions. Confirm setting on site.
- C. Identify the pressure sensor and its normal setting with a 150 mm (6 inch) square red-white laminated plastic tag engraved to read "LOSS OF WATER PRESSURE SENSOR - NORMAL SETTING 210 kPa". Confirm wording prior to manufacture.

3.08 INSTALLATION OF FLOW ALARM SWITCH(ES):

- A. Provide water flow alarm switch(es) in accessible location(s) in zone piping where shown. Install in accordance with the manufacturer's instructions and connect with piping as indicated.
- B. Adjust to suit site water pressure conditions. Check and test operation.
- C. Identify each switch with a 150 mm (6 inch) square red-white laminated engraved plastic tag. Confirm wording prior to manufacturer.

3.09 INSTALLATION OF ALARM CHECK VALVE(S):

- A. Provide alarm check valve(s) in wet zone sprinkler piping where shown. Install in accordance with the manufacturer's instructions and connect with piping as indicated.
- B. Check and test operation of valve(s) and adjust as required to suit site water pressure conditions.

3.10 INSTALLATION OF INSPECTOR'S TEST CONNECTIONS:

- A. Provide inspector's test connections with drain piping where required. Terminate drainage piping over a funnel and floor drain unless otherwise shown or specified.
- B. Where drainage pipe discharge cannot be seen from the test connection valve assembly, provide a sight glass.

3.11 INSTALLATION OF FLOW ALARM - TEST CONNECTION CABINETS:

- A. Where shown on the Drawings, install flow alarm switches and inspector's test connection assemblies in flush wall mounted identified cabinets. Confirm locations prior to roughing-in.
- B. Provide all required drainage piping, and, unless otherwise shown or specified, terminate drainage piping over a funnel and floor drain.

3.12 INSTALLATION OF SPRINKLER HEADS:

- A. Provide all required sprinkler heads.
- B. Unless otherwise specified, sprinkler heads are to be as follows:
 - 1. In equipment rooms and rooms in unfinished areas without a finished ceiling - pendant or upright heads.
 - 2. In finished areas without a suspended ceiling - chrome plated pendant or upright heads.
 - 3. In finished areas with suspended ceilings -chrome plated semi-recessed pendant type.
- C. Maintain maximum headroom in areas with no ceilings.
- D. Provide guards for heads where they are subject to damage.
- E. Provide high temperature heads in equipment rooms and similar areas over heat producing or generating equipment.
- F. Coordinate sprinkler head locations in areas with suspended ceilings with the location of lighting, grilles, diffusers, and similar items recessed in or surface mounted on the ceiling in accordance with the reflected ceiling plans. In areas with lay-in tile, centre the sprinkler head both ways in the lay-in tile wherever possible. Confirm locations prior to roughing-in.

3.13 INSTALLATION OF SPARE SPRINKLER HEAD CABINET:

- A. Supply a full complement (to fill cabinet) of spare sprinkler heads of the types used (minimum 4 of each type) and place in a wall mounting storage cabinet located adjacent the sprinkler system "head end" equipment where later directed.

3.14 STANDPIPE SYSTEM PIPING INSTALLATION REQUIREMENTS:

- A. Perform all required standpipe system Work.
- B. All pipe sizes, quantity of fire hose cabinets, and layout of Work shown on the Consultants' Drawings are to assist you during the tendering period. Do not reduce the size of the fire main or re-route the main unless approved.
- C. Provide all required standpipe system piping. Do all piping work in accordance with requirements of NFPA No. 14 "STANDPIPE AND HOSE SYSTEMS", Utah Regulations, and "reviewed" shop drawings. Pipe, unless otherwise specified, is to be as follows:
 - 1. For underground pipe inside or outside the building - Ipex "BLUE BRUTE" Class 200 DR14 rigid PVC, FM approved pipe and fittings, braced and secured at bends and tees with concrete thrust blocks in accordance with Municipal standards and details. All non ferrous piping shall be changed to ferrous piping prior to entering the building (i.e., changed before passing through basement floor or slab on grade).
 - 2. Piping inside building and above ground - Schedule 40 grooved end mild black steel with Victaulic fittings and couplings, or with screwed fittings and joints for pipe to and including 50 mm (2 inch) diameter, and with welded fittings and joints for pipe 65 mm (2-1/2 inch) diameter and larger pipe.
- D. Slope all horizontal piping so that it may be completely drained. Provide capped drain points.
- E. Provide a pressure gauge at the highest outlet in each standpipe riser. Locate gauges so that they can be read easily. Where possible, locate gauges in fire hose cabinets. See Section 20 05 00 for pressure gauge requirements.
- F. When standpipe Work is complete, test the system in accordance with requirements of Chapter 11 of NFPA No. 14, and complete and submit documentation specified in Chapter 11.

3.15 INSTALLATION OF FIRE HOSE CABINETS:

- A. Provide fire hose cabinets where shown.
- B. Confirm exact cabinet locations prior to roughing-in.

- C. Install fire hose cabinets 1372 mm (54 inches) above finished floor to top of cabinet unless otherwise noted on drawings.
 - D. Install surface mounted fire hose cabinets in the parking garage area on floor to ceiling prime coat painted structural steel frameworks where shown.
- 3.16 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 21 13 00

WET-PIPE FIRE SUPPRESSION SPRINKLER SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Design and provide new automatic wet pipe fire suppression sprinkler systems for the areas indicated and in compliance with Contract Documents.
- B. Design and provide new fire water service entrance for wet-pipe system.
- C. The Work of this Section shall include all labor, materials, tools, equipment and appurtenances, and performing all operations necessary to furnish and install complete and operable systems in accordance with this Section of these Contract Specifications, the Contract Drawings, and the codes and standards listed herein.
- D. Coordinate with the Local Water Department & Utility as to any Local restrictions or requirements relative to backflow prevention devices and metering.
- E. Provide a licensed Fire Protection Professional Engineer to design the systems.

1.02 REFERENCES:

- A. Except as specified herein, the latest edition of the standards listed below form a part of this Specification to the extent referenced in this Section. Where earlier editions of standards are adopted as referenced in applicable codes, those shall govern. The publications are referred to within the text by the basic designation only.
- B. In each of the standards referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears.
- C. ASTM International (ASTM):
 - 1. A36: Carbon Structural Steel
 - 2. A47: Malleable Iron Castings
 - 3. A53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
 - 4. A536: Ductile Iron Castings
 - 5. A795: Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
- D. American Society Of Mechanical Engineers (ASME):

1. A17.1/CSA B44: Safety Code for Elevators and Escalators
 2. B1.20.1: Pipe Threads, General Purpose (Inch)
 3. B16.1: Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125 lb.
 4. B16.3: Malleable Iron Threaded Fittings
 5. B16.4: Cast Iron Threaded Fittings
 6. B16.9: Factory-Made Wrought Steel Butt- Welding Fittings
 7. B16.11: Forged Fittings, Socket-Welding and Threaded
 8. B16.21: Nonmetallic Flat Gaskets for Pipe Flanges
 9. B18.2.1: Square and Hex Bolts and Screws Inch Series)
 10. B18.2.2: Square and Hex Nuts (Inch Series)
 11. B31.1: Power Piping
 12. B40.1: Gauges - Pressure Indicating Dial Type
 13. BPV X: Boiler Pressure Vessel Code – Welding and Brazing Qualifications
- E. American Society Of Sanitary Engineering (ASSE):
1. 1013: Reduced Pressure Principle Backflow Prevention Assemblies and Reduced Pressure Principle Fire protection Backflow Prevention Assemblies.
 2. 1015: Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies
 3. 1048: Double Check Detector Fire Protection Backflow Prevention Assemblies
- F. American Welding Society (AWS):
1. D10.9: Qualification of Welding Procedures and Welders for Piping and Tubing
- G. American Water Works Association (AWWA):
1. C104: Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
 2. C105: Polyethylene Encasement for Ductile-Iron Pipe Systems
 3. C111: Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
 4. C151: Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids

5. C500: Metal Seated Gate Valves for Water Supply Source
 6. C651: Disinfecting Water Mains
 - H. FM Global (FM):
 1. P7825: Approval Guide
 2. Data Sheet 2-2: Installation Rules for Suppression-Mode Automatic Sprinklers.
 3. Data Sheet 2-8: Earthquake Protection for Water-Based Fire Protection Systems.
 - I. Foundation for Cross-Connection Control and Hydraulic Research (FCCCCHR):
 1. List of Approved Backflow Prevention Assemblies
 - J. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):
 1. SP-58: Pipe Hangers and Supports - Materials, Design and Manufacture
 - K. National Fire Protection Association (NFPA)
 1. 13: Installation of Sprinkler Systems
 2. 24: Installation of Private Fire Service Mains and Their Appurtenances
 3. 25: Inspection, Testing, and Maintenance of Water Based Fire Protection Systems
 4. 291: Fire Flow Testing and Marking of Hydrants
 - L. Underwriters Laboratories (UL)
 1. 04: Fire Protection Equipment Directory
 2. 262: Gate Valves for Fire-Protection Service
 3. 668: Hose Valves For Fire Protection Service
 4. 789: Indicator Posts for Fire-Protection Service
 5. Fire Prot Dir: Fire Protection Equipment Directory
- 1.03 SYSTEM REQUIREMENTS:
- A. General:
1. Wet-pipe sprinkler system shall be provided in areas indicated on the Drawings. The system shall comply with the requirements indicated on the Drawings and NFPA 13 edition adopted by Provo Utah. Connection to the water supply line shall

be as shown on the drawings. Design automatic fire suppression sprinkler systems in accordance with the required and advisory provisions of NFPA 13, hydraulic calculations using the area/density method for uniform distribution of water over the design area. Each system shall include materials, accessories, and equipment inside and outside the building to provide each system complete and ready for use. Design and provide each system to give full consideration to blind spaces, piping, electrical equipment, ducts, and other construction and equipment in accordance with detailed working drawings to be submitted for acceptance. Locate sprinkler heads in a consistent pattern with ceiling grid, lights, and air supply diffusers. Devices and equipment for fire protection service shall be UL Fire Prot Dir listed or FM APP GUIDE approved for use in wet pipe sprinkler systems.

B. Location of Sprinkler Heads:

1. Sprinkler heads shall be uniformly spaced to ensure full area coverage. Spacing of sprinklers and position and orientation of sprinklers in relation to the ceiling, walls, and obstructions shall conform to NFPA 13 for the hazard occupancy indicated. Maximum sprinkler head spacing shall not exceed limits specified in NFPA 13 for the corresponding hazard occupancy.

C. Water Distribution:

1. Distribution shall be uniform throughout the area in which the sprinkler heads will open. Discharge from individual sprinklers in the hydraulically most remote area shall be not less than 100 percent of the specified density.

D. Density of Application of Water:

1. Size pipe to provide the indicated density when the system is discharging the specified total maximum required flow.

E. Sprinkler Discharge Area:

1. Sprinkler discharge area shall be the hydraulically most remote area as defined in NFPA 13.

F. Outside Hose Allowances:

1. Hydraulic calculations shall include the indicated allowance for outside hose streams.

G. Friction Losses:

1. Calculate losses in piping in accordance with the Hazen-Williams formula with 'C' value as specified in NFPA 13 for the piping material employed. Velocity in the sprinkler piping shall be limited to a maximum of 20 ft/sec (0.0061 km/s).

H. Water Supply:

1. Base hydraulic calculations on the indicated static pressure, available flow and corresponding residual pressure at the indicated fire hydrants. Provide the indicated pressure cushion between total calculated demand and the water supply.

I. Seismic Design Requirements:

1. Conform to the seismic design requirements specified in NFPA 13. Hangers, supports and through -penetrations shall be designed to protect piping and valves from earthquake damage.

1.04 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00. Provide duplicate submittals to the Engineer & CM and the Owner's insurance underwriter for review and acceptance.

1. Certificate of Design: Submit a completed certificate of design prior to start of design work. See Section 01 33 00 for certificate form.
2. Shop Drawings
 - a. Working Drawings - Prepare 24 by 34 inch detail working drawings of sprinkler heads and piping system layout in accordance with NFPA 13, "Working Drawings (Plans)." Show data essential for proper installation of each system. Show details, plan view, elevations, and sections of the systems supply and piping. Drawings shall clearly show location of sprinkler heads with spacing dimensions as well as orientation of sprinkler heads in relation to obstructions; piping system layout including valve risers and trim, inspectors test connections, fire department connection, gauges, system drains, isolation valves, water flow alarms; and support and hangers. Building sections shall show typical branch line, main line and sprinkler head elevation above the floor. Show point to point electrical wiring diagrams. Submit Working Drawings stamped and signed by the Fire Protection Engineer.
 - b. Coordination Drawings - Prepare as specified in Paragraph "Cooperation and Coordination with Other Trades" of this Section.
3. Product Data - Annotate descriptive data to show the specific manufacturer, model, type, size, capacity, curves, wiring diagrams, options, etc. of each item.
 - a. Pipe, fittings and mechanical couplings
 - b. Valves
 - c. Post indicator valves
 - d. Valve boxes

- e. Buried utility warning and identification tape
 - f. Sprinkler heads
 - g. Alarm check valves
 - h. Fire department connections
 - i. Sight drains
 - j. Backflow preventers
 - k. Pressure gauges
 - l. Audible alarms
 - m. Alarm initiating devices
 - n. Pipe hangers and supports
 - o. Access panels
 - p. Identification signs
 - q. Paint
4. Hydraulic Calculations
- a. Sprinkler system design - Prepare computer program generated hydraulic calculations in accordance with NFPA 13 to substantiate compliance with hydraulic design requirements. Submit name of software program used. Submit hydraulic calculations stamped and signed by the Fire Protection Engineer.
 - b. Provide hydrant flow test data less than one year old conforming to NFPA 291. In case of a winter test, provide comparison to local water department tests or estimates of minimum summer flow and pressure for basis of design. The lesser combined flow and pressure test results shall be used for the hydraulic design of the system.
5. Certification - Submit documentation certifying completion of the following items in compliance with this Section.
- a. Preliminary tests
 - b. Flushing
 - c. Manufacturers' services

- d. Disinfection
- 6. Spare Parts and Special Tools:
 - a. Include a list of spare parts as recommended by the manufacturer of each system component, where applicable. Each spare part shall be listed with the current unit price.
 - b. Include a list of special tools and test equipment required for maintenance and testing.
- 7. Record Drawings
 - a. 24 x 34 inch Record Drawings of each system for record purposes, stamped and signed by the Fire Protection Engineer, shall be submitted not later than 30 days after the final system test is successfully completed. The drawings shall be on bond paper with title block.
- 8. Test Procedures:
 - a. Procedures for hydraulic test, alarms test and final acceptance test shall be submitted 14 days prior to the corresponding test.
- 9. Test Reports - Prepare as specified in Part 3 of this Section.
 - a. Formal tests and inspections
 - b. Backflow preventer tests.
- 10. Certificates and Licenses - Prepare as specified in Part 1 of this Section.
 - a. Qualifications of Installer
 - b. Qualifications of Construction Supervisor
 - c. Qualifications of Fire Protection Engineer.
- 11. Operation and Maintenance Manuals - Prepare manuals in accordance with Section 01 78 23. Submit a certified list of qualified service organizations for support of the equipment which includes their addresses and qualifications.
 - a. Sprinkler heads
 - b. Valves
 - c. Alarm check valves
 - d. Audible Alarms

e. Alarm initiating devices

f. Backflow preventers

12. Closeout Submittals

a. Record Drawings - Prepare as specified in Part 1 of this Section.

1.05 QUALITY ASSURANCE:

A. Provide in accordance with Section 01 43 00 and as specified.

B. Comply with requirements of authority having jurisdiction for submittal, approvals, materials, hose threads, installation, inspections, and testing.

C. Comply with requirements of Owner's insurance underwriter for submittal, approvals, materials, installation, inspections, and testing.

D. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with the following:

1. NFPA 13.

E. Qualifications of Installer:

1. Prior to installation, submit data showing the name and license of the installing contractor and that he has successfully installed systems of the same type and design as specified herein. Data shall include names and locations of at least five installations of similar size and scope that are in compliance with the requirements of the authority having jurisdiction. Indicate type and design of each system and certify that each system has performed satisfactorily in the manner intended for not less than 18 months. The installing contractor shall be licensed to perform applicable fire protection systems installation and alterations and service such systems in the state in which the project is located.

2. Qualifications of Welders: Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures, welders and welding operators shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Authority Having Jurisdiction shall be notified 24 hours in advance of any required testing and the tests shall be performed at the work site. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Prior to installation, submit data for acceptance showing the name and certification of each welder and welding operator to be used on the project. Submit each welder's identification symbols, assigned number, or letter, used to identify work of the welder. Welders making defective welds after

passing a qualifications test shall be given requalification test and, upon failing to pass this test, shall not be permitted to work on the Contract.

- a. Each welder shall have a copy of a certified ASME qualification test report. Conduct a qualification test for each welder and submit results for acceptance.
- b. Submit welding procedure specifications for metals included in the Work.

F. Qualifications of Construction Supervisor

1. Provide a Construction Supervisor with a minimum of 5 years of experience in fire protection construction supervision who shall be responsible for the installation of the Work of this Section of the Contract Specifications. The Construction Supervisor shall be licensed to perform applicable fire protection systems supervision in the state in which the project is located. Prior to installation, submit data for acceptance showing the name and license of the Construction Supervisor.

G. Fire Protection Engineer Qualifications: Hydraulic calculations, working drawings, record drawings, and installation inspection reports shall be prepared by, or under the supervision of, an individual who is experienced with the types of work specified herein, and is currently licensed as a Fire Protection Professional Engineer in the state where the Project is located. Submit data for acceptance showing the name and license of Fire Protection Engineer with such qualifications at, or prior to, submittal of hydraulic calculations and working drawings.

H. Tests shall be conducted in presence of authorities having jurisdiction. Contractor shall notify the authorities having jurisdiction and Engineer & CM minimum five days prior to performing tests.

1.06 DELIVERY, STORAGE AND HANDLING:

A. Provide in accordance with Section 01 66 10 and as specified.

B. Shipping:

1. All equipment, material and spare parts shall be shipped, stored, handled and installed in such a manner as not to degrade quality, serviceability, or appearance. Equipment and material warranties shall not be voided by actions of the Contractor.
2. Ship equipment, material and spare parts complete except where partial disassembly is required by transportation regulations or for protection of components.
3. Pack spare parts in containers bearing labels clearly designated contents and pieces of equipment for which intended.

4. Deliver spare parts at same time as pertaining equipment. Deliver to Owner after completion of work.

C. Receiving:

1. All equipment, material and spare parts shall be delivered to the site in original packages or containers bearing the manufacturer's labels and product identification.
2. Inspect for damage and correctness, and inventory items, upon delivery to site.
3. Store equipment, material and spare parts protected for the weather, humidity and temperature variations, dirt and dust or other contaminants. Store and safeguard in accordance with manufacturer's recommendations.

1.07 SPECIAL REQUIREMENTS:

A. Refer to applicable sections of Division 1 with regard to providing the following:

1. Submittal of manufacturer's specifications, catalog data, descriptive matter, illustrations, diagrams, etc., including complete motor data for all equipment
2. Nameplates
3. Foundations, installations, and grouting
4. Operating and maintenance instructions and parts lists
5. Lubricants
6. Special tools
7. Bolts, anchor bolts, and nuts
8. Concrete inserts
9. Sleeves

1.08 COOPERATION AND COORDINATION WITH OTHER TRADES:

- A. Work shall be performed in cooperation with other trades on the project and so scheduled as to allow efficient completion of the project. Materials and equipment shall be installed as fast as conditions will permit, and installed promptly.
- B. Furnish to all other trades advance information on location and size of all concrete pads, chases, frames, boxes, sleeves, and openings needed for the Work, and also furnish layout information and shop drawings necessary to permit other trades affected by the Work to install their work properly coordinated and without delay.

- C. Where there is evidence that Work installed interferes with the work of other Sections, assist in working out space conditions to make satisfactory adjustments.
 - D. With the acceptance of the Engineer & CM and without extra cost to the Owner, make reasonable modifications in Work specified under this Section of the Contract Specifications required to coordinate with normal structural interference's, or for proper execution of specified work.
 - E. If work is installed before coordinating with other trades so as to cause interference with the work of such trades, make all necessary changes in Work under this Section of the Contract Specifications at no additional cost to the Owner.
 - F. Protect all materials and work of other trades from damage that may be caused by the Work required under this Section of the Contract Specifications and be responsible for repairing any damages caused by such work without any additional cost to the Owner.
 - G. Follow Contract Drawings in layout work. Check Contract Drawings of, and coordinate with, other trades to verify special provisions, installation requirements and spaces in which Work provided under this Section of the Contract Specifications will be installed. Maintain maximum headroom or space conditions at all points. Where headroom or space conditions appear inadequate, notify the Engineer & CM before proceeding.
 - H. Prepare and submit for acceptance 3/8-inch = 1 foot-0 inches scale or larger working plans and sections, clearly showing how this Work is to be installed in relation to the work of other Sections. Coordination Drawings shall be based upon accepted equipment submittals. [The Sheetmetal Ductwork Trade will prepare ductwork shop drawings used to work out the coordination of all work of all trades as specified in each applicable Section. Show and coordinate the Work of this Section on said Coordination Drawings.
 - I. Attend regular coordination and job progress meetings required.
- 1.09 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION:
- A. Access panels shall be furnished under this Section and installed by the trade responsible for the appropriate Section of the Contract Specifications for the surface upon which the panels are mounted. Prepare a schedule showing location, size and function of all required access panels and deliver schedule to representatives of all installing trades.
 - B. Inserts and anchor bolts shall be furnished under this Section and installed under Section 03 30 00. Prepare a schedule showing location, size and function of all required inserts and anchor bolts and deliver schedule to representative of the installing trade.
 - C. Pipe sleeves shall be furnished under this Section and installed by the trade whose finished interior surfaces will be penetrated. Prepare a schedule showing location, size and function of all required pipe sleeves and deliver schedule to representatives of all installing trades.

1.10 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION:

1.11 REMOVAL WORK:

- A. Particular care shall be taken to avoid creating hazards on the site or causing disruption of service of unaffected spaces and/or systems.

1.12 ELECTRICAL WORK:

- A. All electrical apparatus and controls associated with equipment installed under this Section will be furnished and mounted under this Section. All wiring of electrical apparatus and controls to the fire alarm control panel will be furnished and installed by Division 26.
- B. When motors and other associated electrical apparatus furnished are larger than sizes indicated on the Contract Drawings, the cost of additional electrical service and related work shall be included under the Section that furnished that motor.
- D. Provide wiring in conduit as specified in Division 26.

1.13 CODES, PERMITS AND FEES:

- A. Except for additional requirements as specified or indicated under the Work of this Section, materials, workmanship and equipment shall conform with the governing edition of the following regulations, and agency requirements. In the Sprinkler Code referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears.
 - 1. State and Local Building Codes including, but not limited to, NFPA 13 as adopted by the State of Utah, the Utah Building Code, and the Utah Plumbing Code.
 - 2. Utah Department of Environmental Protection
 - 3. Local Fire Department
 - 4. Local Water and Sewer Authority or Department
 - 5. Occupational Safety and Health Administration (OSHA)
 - 6. Any other local codes or requirements of Authorities Having Jurisdiction.
- B. Pay for all fees and give all notices, file all plans, obtain all permits and licenses, and obtain all necessary approvals from Authorities Having Jurisdiction. Deliver all certificates of inspection to the Authorities Having Jurisdiction. No work shall be covered before examination and approval by Authorities Having Jurisdiction. Replace imperfect or condemned work to conform to inspectional requirements, satisfactory to the Owner, Engineer & CM and Authorities Having Jurisdiction without extra cost to the

Owner. If Work is covered before inspection and acceptance, pay costs of uncovering and reinstalling the covering, whether it meets contract requirements or not.

1.14 RECORD DRAWINGS:

- A. Prepare and maintain Record Drawings to meet the requirements of this Section of the Contract Specifications.
- B. As work progresses and for the duration of the Contract, maintain a complete and separate set of prints of Contract Drawings at the job site at all times. On a daily basis, record work completed and all changes from original Contract Drawings clearly and accurately, including work installed as a modification or addition to the original design such as change orders, instructions issued by the Engineer & CM, or conditions encountered in the field. Record valve tags as they are installed. In addition, take photographs of all concealed equipment in gypsum board ceilings, shafts, underground (buried) piping routes and supports and other concealed, inaccessible work. At completion of work, make copies of photographs with written explanation on back. These shall become part of Record Drawings.
- C. Record Drawings shall show as-built condition of all items required by NFPA 13 for Working Drawings (Plans). Remove all superceded data to show the completed work.
- D. The Record Drawings will be used as a guide for determining the progress of the Work installed. They shall be inspected on a regular basis and shall be corrected immediately if found inaccurate or incomplete. Requisitions for payment will not be authorized until the Drawings are accurate and up-to-date.
- E. At completion of Work provide a complete set of cad-drafted Record Drawings on bond paper showing all systems as actually installed. The Contract Drawing electronic CAD files will be made available for this Contractor's use to serve as backgrounds for the Record Drawings. Provide all drawings necessary to show the required record information. Submit three sets of cad-drafted prints to the Engineer & CM for comments as to compliance with this Section. Make all modifications so noted by the Engineer & CM. Final Record Drawings shall be on bond paper.
- F. Certify the accuracy of the record drawings. Record Drawings shall be stamped and signed by the Fire Protection Engineer. Record Drawings shall become the property of the Owner.
- G. When required by jurisdiction, submit the Record Drawings for approval by the Authority Having Jurisdiction in a form acceptable to the jurisdiction.

1.15 MAINTENANCE ACCESSORIES AND TOOLS:

- A. All special tools necessary for the operation and maintenance of the Fire Protection system and equipment shall be furnished. Wrenches for the removal of each type of

sprinkler head installed shall be furnished within the spare sprinkler head cabinet at the Alarm Check Valve assembly or where directed by the Engineer & CM.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Material and equipment for fire protection service shall be UL 04 Fire Prot Dir listed and/or FM P7825 approved for use in wet pipe sprinkler systems where such classes of material and equipment are available as listed or approved by these organizations. Where the terms “listed” or “approved” appear in this Section, such shall mean listed or approved in the aforementioned directories.
- B. Where applicable, all products requiring approval by the Utah Department of Public Safety shall be so approved.
- C. All components subject to pressure shall be rated for minimum 175 psig working pressure.

2.02 BURIED PIPING SYSTEMS:

A. Pipe and Fittings:

- 1. Provide pipe and fittings conforming to NFPA 24 for piping under the building and outside of building walls. Minimum pipe size shall be 6 inches (DN 150). Minimum depth of cover shall be 5 feet (1.5 meter) at finish grade. Piping beyond 5 feet (1.5 meter) outside of building walls shall be provided under Section 33 10 00.
- 2. Piping shall be AWWA C151/A21.1, Class 52, outside coated, double cement line ductile iron pipe and fittings. Fittings shall have 250 psig rating. Lining shall be seal coated and shall conform with AWWA C104/A21.4. Coat exterior of buried piping and fittings with coal tar pitch varnish coating. Provide mechanical type push on joints with AWWA C111/A21.11 gaskets for buried piping and AWWA C111/A21.15 flange joints with full ring gaskets for above ground piping at termination of buried piping inside the building. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used.
- 3. Provide socket clamps with tie rods at each change in direction, coat with asphaltum. Anchor joints in accordance with NFPA 24. Provide concrete thrust block at all changes in direction and at the elbow where the pipe turns up toward the floor. Restrain the pipe riser with steel rods from the elbow to the flange above the floor.

B. Valves:

1. Provide as required by NFPA 24. Valves shall be gate valves conforming to AWWA C500 or UL 262. Valves shall have cast iron body and bronze trim. Valves shall open by counterclockwise rotation.

C. Wall Indicator Valves

1. Provide with operating nut located about 3 feet (1 meter) above finish grade with lever lockable in the open valve position. Gate valves for use with indicator post shall conform to UL 262. Indicator posts shall conform to UL 789. Provide each indicator post with one coat of primer and two coats of red enamel paint. Provide padlock and three (3) keys.

D. Valve Boxes

1. Except where indicator posts are provided, for each buried valve, provide adjustable cast-iron or ductile-iron valve box of a suitable size. Provide cast-iron or ductile-iron cover for valve box with the word "WATER" cast on the cover. The box shaft diameter shall be suitable for the valve on which the box is to be used, but not less than 5.25 inches (134 mm). Coat cast-iron and ductile-iron boxes with bituminous paint applied to a minimum dry-film thickness of 10 mils.

E. Buried Utility Warning and Identification Tape

1. Detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches (76.2 mm) minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall read "CAUTION BURIED WATER PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.03 ABOVEGROUND PIPING SYSTEMS:

- A. Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing pipe fittings; bushings shall not be permitted. Perform welding in the shop; field welding shall not be permitted.

B. Pipe, Fittings and Mechanical Couplings:

1. NFPA 13, except as modified herein. Plain-end fittings with mechanical couplings and fittings which use steel gripping devices to bite into the pipe when pressure is applied will not be permitted. Steel piping with wall thickness less than Schedule 30 shall not be threaded. Side outlet tees using rubber gasketed fittings shall not be permitted. Welding shall not be permitted on galvanized pipe.

2. All empty piping that may be periodically filled with water including, but not limited to, drain piping, test piping, and fire department connection piping up to the check valve and piping from alarm check valve to water motor gong shall be hot dipped galvanized inside and out.
3. Schedule 40 black steel pipe shall be ASTM A53, Type E, Grade A or B, or ASTM A795, Type E, Grade A. Schedule 10 black steel pipe shall be ASTM A135, Type E, Grade A. Steel piping shall be Schedule 40 for sizes 1 inch and smaller, Schedule 40 for sizes 1-1/4 to 6 inch (DN 32 to 150). Unless otherwise specified to be hot-dipped galvanized, pipe shall be black steel pipe and shall be pre-oxidized with a suitable protective coating.
4. Stainless steel piping shall be ASTM A312, Schedule 40, series 300 stainless steel pipe and fittings, with screwed joints in accordance with specification ASME B1.20.1.
5. Pipe 1 inch (DN 25) and smaller shall be joined by screwed joints in accordance with specification ASME B1.20.1.
6. Schedule 40 pipe 2-1/2 inch (DN 65) and larger shall be joined by flanged joints, welded joints, or by mechanical couplings. For mechanical couplings, pipe ends shall have cut grooves. Roll grooving shall not be permitted. Schedule 40 pipe 2 inch (DN 50) and smaller shall have screwed joints.
7. Schedule 10 pipe 1-1/4 inch (DN 32) and larger shall be joined by welded joints in accordance with AWS D10.9 or by mechanical couplings. For mechanical couplings, pipe ends shall have rolled grooves. Cut grooving shall not be permitted.
8. Screwed fittings shall be cast iron, class 125, black, and in accordance with ASME B16.4 or malleable iron, class 150, black, and in accordance with ASME B16.3.
9. Welded fittings shall be steel, standard weight, black, and in accordance with ASME B16.9 and ASME B16.11.
10. Flanged fittings shall be cast iron, short body, class 175 and in accordance with ASME B16.1, ASME B16.21, ASME B18.2.1, and ASME B18.2.2. Provide hexagon head machine bolts, hexagon head nuts, and washers, all heavy finished cadmium plated.
11. Rubber gasketed grooved mechanical couplings and fittings shall be NFPA 13 listed and approved and consist of combination housings and gaskets. Housings shall either be malleable iron ASTM A47 or ductile iron ASTM A536 and shall be hot-dipped galvanized where galvanized piping is specified to be used. Gasket material shall be Listed for the intended service and shall be Grade "E", EPDM.

Fittings, mechanical couplings, and rubber gaskets shall be supplied by the same manufacturer.

- a. Mechanical couplings shall be Victaulic Style 07 "Zero Flex" couplings for rigid connections in equipment rooms; Style 77 standard flexible couplings at pumps and vibration producing equipment; Style 77 at flexure points in equipment rooms and Style 75 at flexure points elsewhere (to meet seismic requirements); Style 72 outlet couplings; Style 750 reducers; and Style 741 "Vic-Flange" adapters at all valves and equipment connections 2-1/2 inch (DN 65) and larger.
 - b. Victaulic "installation-ready" couplings may be substituted Style 107 for Style 07, and Style 177 for Styles 77 and 75.
12. Expansion: When crossing building expansion or seismic joints, expansion or seismic loops, as required by NFPA 13, shall be installed with the appropriate couplings to allow for expansion in agreement with that as provided for by the building joint. Piping shall be securely anchored to the building structure on both sides of the building expansion and/or seismic joint.

C. Sprinkler Heads

1. Provide nominal 1/2-inch (12.7 mm) or 3/4-inch (19.1 mm) orifice sprinkler heads, 175 psig (1,207 kPa) working pressure. O-rings will not be permitted in sprinkler heads. Release element of each head shall be of the ordinary temperature rating or higher as required by NFPA 13. Provide corrosion-resistant sprinkler heads and sprinkler head guards as required by NFPA 13. Sprinklers shall be used in accordance with their listed and approved coverage limitations.
2. Unless otherwise specified or indicated, sprinkler heads shall be of conventional design, standard response or quick response, standard coverage, upright style. Extended coverage sprinklers shall not be used.
3. Sprinkler heads located in uninhabited areas without ceilings (mechanical rooms, storage rooms, etc.) and combustible concealed spaces above ceilings shall be of conventional design, upright style, and shall have a rough brass finish.
4. Sprinkler heads located in inhabited areas without ceilings shall be of conventional design upright style and shall have a polished chrome finish.
5. Sprinkler heads in suspended ceilings shall be of conventional design, recessed pendent style, low profile ceiling plate (escutcheon) and shall have a polished chrome finish.
6. Sprinkler heads located at skylights shall be conventional design, polished chrome finish, style to suit, upright, pendent or sidewall.

7. Sprinkler heads to protect unheated spaces shall be individual dry sidewall, pendent or upright style each connected separately to the wet-pipe sprinkler piping.
8. All recessed sprinkler heads shall be of the adjustable type.
9. Provide wax-coated heads in corrosive areas.
10. Sprinkler Head Guards: Provide head guards on all sprinkler heads in mechanical rooms, in storage rooms, in pump rooms, on all pendent-mounted sprinkler heads within 7 feet-0 inches (2.1 meters) of any floor or stair, and elsewhere where susceptible to accidental damage. Guards shall be constructed of galvanized wire with locking device to permit authorized removal for sprinkler and head repair. Do not provide guards on sidewall heads.
11. Spare Heads Cabinet: Provide metal cabinet with extra sprinkler heads, and two sprinkler head wrenches for each type of head adjacent to each alarm valve riser. The number and types of extra sprinkler heads shall be as specified in NFPA 13.

D. Valves

1. NFPA 13. Provide valves of types approved for fire service. Gate valves shall open by counterclockwise rotation.
 - a. Gate Valves 2-1/2 Inch (DN 65) and Larger: Outside screw and yoke indicating type, iron body, bronze mounted gate valves, straightway pattern, flanged ends, 175 psig (1,207 kPa) working water pressure, Jenkins Figure No. 825CJ or equivalent acceptable product.
 - b. Gate Valves 2 Inch (DN 50) and Smaller: Outside screw and yoke indicating type, bronze body, straightway pattern, screwed ends, 175 psig (1,207 kPa) working water pressure, Jenkins Figure No. 820J or equivalent acceptable product.
 - c. Butterfly Valves: Indicator type, built-in double pole/double throw tamper switch, 175 psig (1,207 kPa) working water pressure. Butterfly valves of sizes up to 6 inch (DN 150) shall have locking type handles. Butterfly valves 8 inch (DN 200) size shall have gear operators, Victaulic No. 708-W. Butterfly valves may be substituted for gate valves except where NFPA/Underwriter specifically requires an outside screw and yoke gate valve.
 - d. Ball Valves 3 Inch (DN 80) and Smaller: Brass body, chrome plated brass ball with nylon seat, cadmium plated vinyl insulated handle, female NPT inlet and outlet, 600 psig (4137 kPa) working water pressure, Potter Roemer 4400 Series or equivalent acceptable product.

- e. Check Valves 2-1/2 Inch (DN 65) and Larger: Iron body, bronze mounted, flanged ends, swing type for placement in the horizontal position, 175 psig (1,207 kPa) working water pressure, Jenkins Figure No. 477J or equivalent acceptable product. Provide flanged inspection and access cover plate for check valves 4 inch (DN 100) and larger.
- f. Check Valves 2 Inch (DN 50) and Smaller: Iron body, stainless steel trim, EPDM seal, screwed ends, silent check type, 200 psig (1,379 kPa) working water pressure, Mueller Steam Specialty Figure No. 303-AT, or equivalent acceptable product.
- g. Drain and Inspectors Test Valves: Copper alloy ball valve with integral tamper resistant test orifice, sight glass, tapped and plugged port, and locking kit, suitable for 300 psig non-shock cold water, AGF Manufacturing Inc. Model 1000 or equivalent acceptable product. Orifice size shall be noted on indicator plate and shall equal smallest sprinkler orifice installed in the hydraulically remote area of the sprinkler zone served. Valves shall be line size.
- h. Backflow Preventer Test Valves: 2-1/2 inch (DN 65) hose gate valve, iron body, bronze mounted, straightway or angle pattern, flanged end, 175 psig (1,207 kPa) working water pressure. Provide hose threads to suit local fire department with cap and chain.
- i. Automatic Ball Drip Valve: 1/2-inch (DN 15), bronze body, corrosion resistant metal ball and spring, threaded ends, 175 psig (1,207 kPa) working water pressure.
- j. Pressure Reducing Valves: Pressure control valves shall be designed for use on sprinkler systems to reduce a higher inlet pressure to a lower delivery pressure and automatically maintain that pressure within a close limit, regardless of fluctuations in the higher pressure inlet line. Pressure control valves shall be factory-assembled consisting of a flow control valve, a speed control valve, a pilot operated pressure regulating valve, and complete with trim piping, valves, fittings, pressure gauges, and other ancillary components. Flood valve shall be quick opening, differential diaphragm flood valve with a spring loaded floating clapper, field-replaceable diaphragm and seat rubbers, and flanged connections. Pressure regulating valve shall be direct-acting, single-seated, spring-loaded diaphragm valve with spring range to suit indicated discharge pressure setting. Entire assembly shall be designed for installation in the horizontal or vertical position with minimum 250 psig working water pressure and minimum 150 degrees F operating temperature. Entire assembly shall be factory painted and tested.

E. Alarm Check Valves

1. Provide alarm check valve complete with [variable pressure retarding chamber,] alarm test valve, alarm shutoff valve, check valves, drain valves, pressure gages, and all other appurtenances for the proper operation of the system.
- F. Riser Swing Check Valves
1. Provide riser check valve approved for use in fire service systems complete with drain connection and pressure gauge connections. Valve shall be rated for 250 psig (1,724 kPa) water working pressure and have ductile iron body, ad rubber-faced clapper hinged to access cover.
- G. Fire Department Connections:
1. Provide listed and approved 6 inch single Storz type connections approximately 3 feet (1 meter) above finish grade. Fire department connections shall have hose threads to suit local fire department with brass pin lug caps and chains, and identifying fire department connection escutcheon plate. Provide polished chrome plated finish.
 2. Provide listed single inlet type connections approximately 3 feet (1 meter) above finish grade. Fire department connections shall have hose threads to suit local fire department with pin lug cap and chain, polished brass snoot with rigid end NPT by pin lug hose thread swivel, and identifying fire department connection round brass escutcheon plate. Provide polished chrome plated finish.
- H. Sight Drains
1. Reliable Model B, one inch, to suit.
- I. Backflow Preventers
1. Provide listed and approved double check backflow preventer with OS&Y gate valve on both ends and strainer on inlet. Body shall be epoxy coated cast iron with rubber check valve disks, bronze seats, stainless steel trim, and bronze test cocks. Backflow prevention assemblies shall have current "Certificate of Approval from the Foundation for Cross-Connection Control and Hydraulic Research, FCCCHR . Listing of the specific make, model, design, and size in the FCCCHR shall be acceptable as the required documentation." Double check backflow preventers shall be tested and certified under ASSE 1015.
 2. Provide listed and approved double check detector assembly backflow preventer with OS&Y gate valve on both ends and strainer on inlet. Unit shall be equipped with auxiliary line complete with backflow preventer and water meter. Body shall be epoxy coated cast iron with rubber check valve disks, bronze seats, stainless steel trim, and bronze test cocks. Meter shall read in Cubic Feet per Minute or Gallons per Minute as required by the local water company. Backflow prevention assemblies shall have current "Certificate of Approval from the Foundation for

Cross-Connection Control and Hydraulic Research, FCCCHR [. Listing of the specific make, model, design, and size in the FCCCHR shall be acceptable as the required documentation." Assembly shall be tested and certified under ASSE 1048.

3. For backflow preventer testing, provide downstream of the backflow prevention assembly UL 668 hose valves with National standard male hose threads with cap and chain.

J. Pressure Gauges

1. Pressure gauges shall be listed and approved for fire protection service, ASME B40.1, 3 percent accuracy or better, with wetted parts consisting of bronze bourdon tube and brass socket, and corrosion-resistant ABS case and heat-resistant polycarbonate window. The movement shall be designed to provide shock and vibration resistance. Gauges shall withstand temperatures of minus 40 to 150 degrees F (-40 to 66 degrees C).
2. Gauges shall have a minimum 3-1/2 inch (88.9 mm) diameter face. Dial gradations reading in "PSIG" (bar) shall be such that the normal operating pressure of the system installed shall be indicated near the middle of the scale.
3. Select gauges for use on "wet" systems with pressurized water piping.
4. Gauges shall be equipped with a ball valve shutoff and snubber. An outlet, at least 1/4-inch (6.4 mm) size, plugged for the installation of the inspector's gauge shall be located between each valve and gauge.
5. Provide Dwyer Model 35W or equivalent acceptable product by American, Mueller, Terice, or Ashcroft.

2.04 ALARM SYSTEMS:

A. Audible Alarms

1. Provide alarms of the approved weatherproof and guarded type. Mount alarms outdoors on the exterior walls of each building at the location(s) indicated.
 - a. Provide electric alarm bell(s) to sound locally upon the flow of water in any sprinkler system and/or fire detection system.

B. Alarm Initiating Devices:

1. Provide switches with circuit opener or closer for the automatic transmittal of an alarm over the facility fire alarm system and electric alarm bell where so indicated. Connection of switches to the fire alarm system shall be under Section 28 31 00. Switches shall be listed and approved. Do not install a shutoff valve in the piping between the alarm check valve and any pressure switch.

2. Pressure Switches: Provide pressure actuated adjustable switches designed for use in wet-pipe automatic fire sprinkler systems which shall actuate at 4 to 8 psig. Provide two set[s] of snap action single pole double throw (SPDT) Form C contacts for the automatic transmittal to the fire alarm system. Minimum contact ratings shall be 2.0 amps at 30 VDC. Switches shall have NEMA 4 enclosure with tamper resistant fasteners and be designed for upright mounting (threaded connection down) either indoors or outdoors. Potter-Roemer PS10A Series, Reliable, Gem, Autocall, or equivalent acceptable product.
3. Low Water Pressure Supervisory Switches: Provide pressure actuated adjustable switches designed for use in automatic fire sprinkler systems water supply piping which shall actuate by a low pressure supervisory signal as indicated. Provide one set of snap action single pole double throw (SPDT) Form C contacts for the automatic transmittal to the fire alarm system. Minimum contact ratings shall be 2.0 amps at 30 VDC. Switches shall have NEMA 4 enclosure with tamper resistant cover and be designed for upright mounting (threaded connection down) either indoors or outdoors. Potter-Roemer PS40-1, Reliable, Gem, Autocall, or equivalent acceptable product.
4. Flow Switches: Provide vane-type water flow switches designed for use on Schedule 10 to Schedule 40 steel pipe in wet-pipe automatic fire sprinkler systems. Each flow switch shall be equipped with plastic paddle. Alarm actuating device shall detect a flow of 10 gallons per minute or more, and have mechanical diaphragm controlled retard device adjustable from 10 to 90 seconds and shall instantly recycle. Provide two sets of snap action single pole double throw (SPDT) Form C contacts for wiring to the fire alarm system. Minimum contact ratings shall be 2.0 amps at 30 VDC. Switches shall have NEMA 4 enclosure with tamper resistant fasteners and be designed for vertical or horizontal mounting either indoors or outdoors. Potter-Roemer VSR-F Series, Gem, Reliable, Autocall, or equivalent acceptable product. Flow switches shall be sized for the piping in which installed to ensure proper fit.
5. Tamper (Supervisory) Switches: Provide on all control valves except post indicator valve, closed circuit supervisory tamper switches mounted in accordance with UL standard. Provide supervision against valve closure or tampering of valve. Provide two sets of snap action single pole double throw (SPDT) Form C contacts [for wiring to the fire alarm system. Minimum contact ratings shall be 2.0 amps at 30 VDC. A signal shall be initiated during the first 1/5 of travel distance of the valve/stem from the full open position. Switches shall have NEMA 4 enclosure with tamper resistant fasteners and shall be suitable for indoor installation (outdoor location for post indicator valves), and have sealed and gasketed enclosures. Potter-Roemer OSYSU Series, Gem, Reliable, Autocall, or equivalent acceptable product.

2.05 PIPE HANGERS AND SUPPORTS:

- A. Provide in accordance with NFPA 13.
- B. Attach to steel joists with MSS SP-58, Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor.
- C. Hangers, supports, rods and fasteners shall be steel. Hangers, supports, rods and fasteners shall be hot-dipped galvanized where located in the following rooms: CI Storage 123.

2.06 SUPPLEMENTARY STEEL AND CHANNELS:

- A. Unless otherwise indicated on the Structural Drawings, Provide all supplementary steel and factory fabricated channels required for proper installation, mounting and support of all equipment and systems provided under this Section.
- B. Channels and supplementary steel shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for the specific loading on the system installed herein.
- C. All supplementary steel shall be ASTM A36 factory-formed standard mill finished structural shapes. Channels shall be steel. [Supplementary steel assemblies shall be hot dipped galvanized after fabrication and channels shall be hot dipped galvanized where located in the following rooms: CI Storage 123.

2.07 PIPE SLEEVES:

- A. Sleeves in Masonry and Concrete Walls, Floors, Ceilings, and Flat Roofs: Schedule 40 hot dipped galvanized, standard weight ductile-iron or cast-iron pipe sleeves. Sleeves available from the manufacturer of mechanically adjustable segmented elastomeric seals shall be permitted subject to acceptance by the Engineer & CM. Provide minimum 2 inch high waterstop for sleeves in exterior walls and floors.
- B. Sleeves in Non-Masonry or Non-Concrete Walls, Floors, and Roofs: Hot-dip galvanized steel sheet, 26 gage minimum thickness.
- C. Mechanically Adjustable Segmented Elastomeric Seals: Seals shall have EPDM seal elements and steel hardware with corrosion inhibiting coating.

2.08 PIPE ESCUTCHEONS:

- A. General: Provide pipe escutcheons at all pipe penetrations where penetration is exposed to view as specified herein with inside diameter closely fitting pipe outside diameter.

Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, wall, or ceilings; and pipe sleeve extension, if any. Escutcheons shall be held in place by internal spring tension or set screws.

- B. Provide pipe escutcheons in finished spaces. Pipe escutcheons shall be of stainless steel, anodized aluminum or chrome-plated brass, solid or split hinged.

2.09 DRIP PANS

- A. Examine all Contract Drawings and in cooperation with the Electrical Trade confirm the final location of all new electrical equipment to be installed in the vicinity of new and existing piping. All overhead piping containing liquid or vapor shall be no closer than 3 feet from a vertical line to electrical equipment including, but not limited to, electric motors, controllers, switchboards, panelboards, and similar equipment. Piping is not permitted in Electrical Rooms.
- B. Where the installation of new and existing automatic sprinkler systems piping does not comply with the requirements of the foregoing paragraph, where feasible the piping shall be relocated. Where not feasible, provide drip pans as specified below, except as otherwise indicated on the Contract Drawings.
- C. Provide drip pans fabricated from 14 gauge steel sheet and with edges turned up 2-1/2-inches (63.5 mm). Reinforce top edge, either by structural angles or by rolling top over 1/4-inch (6.3 mm) rod made of same material as drip pan sheet metal. Provide hole and 1 inch (25.4 mm) threaded half coupling for low point drain. Provide hanging brackets of sufficient quantity made of same material as drip pan sheet metal for connecting threaded rods used for suspended drip pans. All joints shall be welded watertight and entire welded assembly sandblasted, degreased and hot dipped galvanized after fabrication. Drip pans in chemical areas shall be 1/4 inch (6.3 mm) thick plastic material that is corrosion resistant against the chemicals present.
- D. Locate drip pans under piping passing over or within 3 feet (0.91 meters) horizontally of material and equipment defined above, and elsewhere as indicated. Hang from structure with rods and building attachments, fasten rods to brackets on sides of drip pan. Carefully pitch to the drip pan low point for drainage. Brace to prevent sagging or swaying. Drip pans shall be installed within 12 inches (304.8 mm) below piping.
- E. Provide 1 inch (25.4 mm) schedule 40 hot dipped galvanized steel drain line from each drip pan and terminate 6 inches (152.4 mm) above the floor at nearest floor drain. In chemical areas, drain lines shall be plastic material same as drip pan material.

2.10 ACCESS PANELS:

- A. Access panels shall give access to each valve and sprinkler in concealed spaces above non removable (hard) suspended ceilings, and to all other concealed parts of the system. Access panels shall be located where indicated on the Contract Drawings, or where

otherwise require accessibility for the proper inspection, operation and maintenance of the system.

- B. Access panels shall be Milcor Type M, 16 inch by 16 inch minimum, as manufactured by Inryco, Inc., or equal. Door shall be constructed of 18 gage galvanized steel with frame constructed of 16 gage galvanized steel. Casing bead shall be galvanized steel. Hinge shall be continuous steel with stainless steel pin. Locks shall be flush, screwdriver operated, with metal cam. Galvanized steel sleeve shall be welded to panel for access to cam lock control. Prime coat shall be factory applied rust-inhibitive light grey paint.

2.11 IDENTIFICATION SIGNS:

- A. Signage shall be safety sign manufacturer standard signs furnished and installed under this section. Comply with NFPA 13. Attach properly lettered and approved metal signs to each audible alarm, control valve and test valve.

2.12 PAINT:

- A. Paint all items specified in Part 3 of this Section.
- B. Paint shall be high solids epoxy with following characteristics:
 - 1. Type: Polyamidoamine, self priming
 - 2. Solids by Volume: Minimum 69 (+/- 2) percent
 - 3. VOC Requirement: Maximum 2.79
 - 4. Number of Coats: Two (2)
 - 5. Dry Film Thickness: 4 to 8 mils per coat
 - 6. Color: Safety Red
- C. Surface preparation, mixing, application, and safety requirements shall be in accordance with the paint manufacturer's printed instructions.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Installation, workmanship, inspection, and testing shall be in accordance with NFPA 13 and NFPA 24, with the additions specified herein. Install piping straight and true to bear evenly on hangers and supports. Keep the interior and ends of new piping and existing piping affected by the Work thoroughly cleaned of water and foreign matter. Keep piping systems clean during installation by means of plugs or other accepted methods. When work is not in progress, securely close open ends of piping to prevent entry of water and

foreign matter. Inspect piping before placing into position. Provide Teflon pipe thread paste on male threads.

- B. Piping shall not be permitted in Electrical Rooms unless otherwise indicated.
- C. Piping and other apparatus shall not be installed in such a manner so as to interfere with the full swing of doors, movement of personnel and equipment, and access to other equipment.
- D. Install aboveground pressurized piping to permit draining of all sections of each piping systems without traps. Pitch piping back to system low points. Provide drain valves at all piping low points.
- E. Make provisions for pipe expansion and contraction with suitable anchors and offsets, expansion joints, or expansion loops. Make provisions in buried piping for differential settlement. Install piping to allow freedom of movement in all planes without imposing undue stress on any section of the main piping, branch piping, equipment and structure.
- F. Buried Piping
 - 1. Pipe bedding and compacted backfill to a point 12 inches (305 mm) above crown of buried pipe shall be provided under this Section of the Contract Specifications in accordance with the requirements of Section 31 22 00. Depth of cover shall be as indicated on the Contract Drawings.
 - 2. Pipe bedding shall be minimum 6 inches (152 mm) deep. Bedding and compacted backfill shall be non-corrosive material such as cleaned, washed sand.
 - 3. Install buried lines in a single trench. Trenches shall be wide enough to permit at least 6 inches (152 mm) spacing between lines and the sides and floor of the trench.
 - 4. Terminate buried piping not more than 6 inches above finished ground surface or floor slab-on-grade.
 - 5. Completely encase buried piping with polyethylene tube or sheet in accordance with AWWA C105.
 - 6. Bury utility warning and identification tape with the printed side up at a depth of 12 inches (305 mm) below the top surface of earth or the top surface of the subgrade under pavements.
- G. Sprinkler Heads Locations
 - 1. Sprinkler head locations shall be coordinated with all surface mounted items, such as cornices, curtains, low soffits and lighting fixtures and shall be located accordingly. Extended escutcheons may be utilized where heads cannot be moved, if accepted by the Engineer & CM.

2. Sprinkler heads and piping locations shall be determined by actual field measurements. Care shall be taken to avoid obstruction of structural members, equipment, fixtures, lighting, ducts, other piping, ceiling tile supports, etc.
3. When sprinkler heads are shown on the reflected ceiling plan, they shall be so located. Unless specifically indicated otherwise, sprinkler heads shall be installed in the centers of tiles.
4. Sprinkler heads are to be provided above suspended ceilings in combustible concealed spaces with 6 inches (153 mm) or greater space between the bottom of joists and ceiling assembly. Sprinklers in these concealed spaces shall be located with deflectors a minimum of 1 inch (25.4 mm) and maximum of 6 inches (153 mm) below the bottom of the joists. Head spacing within these spaces shall not exceed 130 ft² per head. Provide additional heads in concealed spaces not identified on the Contract Drawings or where ducts, equipment, etc. create obstructions.

H. Test Connections

1. Inspector's Test Connections: Provide inspector's test valve approximately **6** feet above the floor in readily accessible location for each sprinkler system or portion of each sprinkler system equipped with a flow or pressure switch. Pipe from the end of the hydraulically most remote part of each system. Provide test connection piping to a drain location that can accept full flow where the discharge will be readily visible and where water may be discharged without property damage. Discharge to janitor sinks or similar fixtures shall not be permitted. Provide smooth bore corrosion resistant discharge orifice of same size as corresponding sprinkler orifice giving flow equivalent to one sprinkler. Provide a precast concrete splash block under each exterior discharge orifice.
2. Backflow Preventer Test Connection: Provide test valves downstream of the backflow preventer assembly. Provide one valve for each 250 gpm (15.8 L/sec) of system demand or fraction thereof. Provide a permanent sign in accordance with paragraph entitled "Identification Signs" which reads, "Test Valve."

I. Main Drains

1. Provide separate drain piping to discharge at safe points outside each building **or to** sight drains of adequate size to readily receive the full flow from each drain under maximum pressure. Provide auxiliary drains as required by NFPA 13. Provide precast concrete splash block under each exterior drain discharge.

J. Pipe Hangers and Supports

1. The hanging and supporting of all piping and equipment shall conform to the requirements of NFPA 13 and the manufacturer's recommendations.

2. Furnish and install safe and substantial means of support for all parts of the piping system. Attach all pipes securely to the structure in correct alignment and pitch, to prevent vibration and to effectively care for expansion and contraction.
3. All piping shall be hung to true alignment, using appropriate hanger arrangements. Wire and strap hangers shall not be permitted. Hangers shall be located so that piping and hangers will be minimum 6 inches (152 mm) clear from other piping, hangers, conduits, lighting fixtures, equipment, ceiling suspension systems, ductwork and other obstructions.
4. Supplementary steel and channels shall be firmly connected to the building construction in a manner accepted by the Engineer & CM, or as otherwise shown on the Contract Drawings. Equipment and piping shall not be supported from metal decking or plaster ceilings.
5. Seismic Pipe Hanging Requirements:
 - a. Seismic protection of all fire suppression piping shall comply with the requirements of NFPA 13. Seismic bracing shall be provided for all piping larger than or equal to 2-1/2 inch (63.5 mm). All feed mains regardless of size shall be braced.
 - b. The Contractor shall submit seismic supports and anchors accompanied by calculations and shop drawings signed and sealed by the Fire Protection Engineer. The calculations are to be provided both to Engineer and FM Global representative at least 2 weeks prior to beginning of construction.
 - c. All mechanical materials and equipment including all pipes shall be supported and anchored to resist the external seismic forces for seismic hazard exposure Group IV. Force shall be resisted without failure or permanent displacement when it is applied in any direction, and shall conform to the specified Building Code.
 - d. The ends or all branch lines shall be provided with an acceptable method of lateral restraint. The use of a wrap around "U" hanger, or band hanger at 45 degree angle is acceptable.
 - e. Acceptable manufacturers of seismic bracing are: TOLCO Incorporated; Corona, California.
 - f. All seismic braces shall be Listed for tension and compression service.
 - g. All braces shall utilize ordinary black steel piping as the prime support member.
 - h. Structural connection
 - (1) All bracing shall be connected to the building's structural members.

- (2) All means of connection to the building's structure and sprinkler pipe shall be Listed for the intended use.
- i. At a minimum, the bracing shall be provided a maximum of 40 feet (12.2 meters) between lateral braces and 80 feet (24.4 meters) between longitudinal braces. However, if the pipe installation positioning selected by the Contractor requires additional bracing, these locations and types of braces shall be submitted for review and shall be provided as part of the base bid.

K. Pipe Through-Penetrations

1. Furnish pipe sleeves where piping passes through walls, floors, ceilings, roofs, and partitions. Holes will be made and sleeves will be installed, and secured in proper position and location during construction by the trade whose element will be penetrated. Such trades include concrete, masonry, steel siding in the case of a steel building, and dry wall in the case of framed construction. Core drilling of concrete may be provided by this Section in lieu of pipe sleeves when cavities in the core-drilled holes are completely grouted smooth. Furnish sleeves of sufficient length to pass through entire thickness of walls, floors, ceilings, roofs, and partitions.
2. Pipe Penetrations Through Building Interior Construction: Provide not less than 1/2" space between exterior of piping or pipe insulation and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation.
 - a. For non-fire rated assemblies, seal at both ends of the sleeve or core-drilled hole with silicone.
 - b. Seal both ends of penetrations through fire rated assemblies to maintain fire resistive integrity with UL listed fill, void, or cavity material. Install firestopping assembly in accordance with UL FRD systems, and as recommended by manufacturer. Completely fill voids flush with the surface. Firestopping for filling voids in floors in which smallest dimension of a void is 4 inches (101.6 mm) or more shall support the floor design load or be protected by a permanent barrier. Damaged, disrupted, or removed firestopplings shall be replaced with new firestopplings as specified in this Section.
3. Pipe Penetrations Through Building Exterior Construction: Provide a mechanically adjustable segmented elastomeric seal, with sleeve sized as recommended by seal manufacturer.
4. Extend sleeves in floor slabs 2 inches above the finished floor. Sleeves through walls shall terminate flush with the finished surface on either side of the wall.
5. Seismic-braced pipe

- a. Proper clearances between penetrating sprinkler system piping, including drains and fire department connections, and any barrier shall be provided. The penetration holes shall be sized such that the hole diameter is 2 inches (50.8 mm) larger for pipe diameters 1-inch nominal to 3-1/2 inch nominal (DN 25 to DN 90), and 4 inches larger for 4 inch (101.6 mm) and larger nominal diameter pipe.
- b. All open space around seismically braced through-penetrations shall be protected by a Listed, flexible through-penetration seal system.

L. Cross Connections and Interconnections

1. No equipment, devices or piping shall be installed which will provide a cross or interconnection between a distribution water supply and a drainage, soil or waste pipe which will permit or make possible the backflow of sewage, polluted water or waste into the water supply system.

3.02 FIELD QUALITY CONTROL:

- A. After piping installation has been completed and prior to initial operation, inspect piping systems for compliance with Contract Drawings, Contract Specifications, and accepted submittals. As part of inspection, perform tests and flushing in compliance with the specified requirements. Have piping tested, and approved by the Fire Protection Engineer before insulating or otherwise concealing. Comply with NFPA 25.

B. Preliminary Tests

1. Perform pressure tests specified herein. Prior to application of test pressure, remove or valve off piping components which may be damaged by test and install a calibrated pressure gage in each system. In the even of leakage, locate and repair leak by remaking joints and/or replacing piping sections and repeat test. Material and equipment used in testing shall be subject to inspection by the Engineer & CM. Provide electricity, instruments, connecting devices, and personnel for the tests. Correct defects in the Work and repeat tests until the Work is in compliance with contract requirements. Owner will furnish water for piping testing up to 10 percent of piping volume to be tested. Pay for test water losses greater than 10 percent. Pressure test each system hydrostatically at 200 psig (1,379 kPa) for a 2 hour period with no leakage or reduction in pressure.
2. Provide alarm tests for each alarm initiating device and audible alarm. Test the audible alarms by flowing water through the inspector's test connection.
3. Provide flow tests for each riser, backflow preventer, and zone.

C. Backflow Preventers Test Report

1. Backflow preventers shall be tested by a locally approved and certified backflow assembly tester. A copy of the test report shall be provided to the Engineer & CM and Owner prior to placing the domestic water system into operation, or no later than 5 days after the test.

D. Formal Tests and Inspections

1. Do not submit a request for formal test and inspection until the preliminary test and corrections are completed and accepted. Submit a written request for formal inspection at least **15** days prior to inspection date. An experienced technician regularly employed by the system installer shall be present during the inspection. At this inspection, repeat any or all of the specified preliminary tests. Correct defects in Work, and repeat tests until Work is in compliance with contract requirements. Furnish equipment, water, electricity, instruments, connecting devices, and personnel for performing tests. The Fire Protection Engineer shall witness formal tests and approve systems before they are accepted. When tests have been completed and corrections made, submit a signed and dated test report, similar to that specified in NFPA 13.

E. Flushing

1. After completion of testing and before placing in operation, flush all new sprinkler piping including feed mains in accordance with Factory Mutual Loss Prevention Data Sheet 2-81, Sprinkler System Maintenance, Section 9.5 using the hydraulic method. Flush entire sprinkler system to remove all foreign matter, under pressure as specified in NFPA 13. Use the permanent fire water service at its maximum available pressure for the source of flushing water. Flush piping through each sprinkler head outlet before sprinkler heads are installed. Flush until water runs clean. Discharge used water to sanitary sewer.

3.03 MANUFACTURERS INSTRUCTIONS:

- A. Obtain instructions from the manufacturer for the proper method of installation and connection of the equipment that is to be installed. Obtain all information that is necessary to facilitate the Work and to complete the project.

DISINFECTION:

- B. Disinfect the new water piping in accordance with the specified Plumbing Code with the additions specified herein or AWWA C651 whichever is more stringent. Fill piping systems with chlorine solution and allow solution to stand. Following the required standing time, flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 ppm, or the residual chlorine content of domestic water supply. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyzed by a certified laboratory, and submit results prior to the new water piping being placed into service. Disinfection of systems supplied by nonpotable water (service water) is not required.

- C. Where it is not possible to disinfect a potable water storage tank as specified above, the entire interior of the tank shall be swabbed with a solution which contains 200 parts per million of available chlorine; and the solution shall then be allowed to stand **3** hours before the tank is flushed and returned to service.
- D. For a potable water filter or similar device, the dosage shall be determined by the Utah Department of Environmental Protection.

3.04 PAINTING:

- A. Provide field painting or shop painting system, under this Section, of the following.
 - 1. Pipe, fittings and valves in all aboveground locations. Color of finish coat shall be safety red.
 - 2. Supplementary steel and channels in chemical areas. Color of finish coat shall match color of structure to which attached.
- B. Field touch-up all damaged shop applied coatings for material and equipment furnished under this Section in accordance with the paint manufacturer's recommendations.
- C. Prepare all surfaces in accordance with the paint manufacturer's recommendations.
- D. Cover all sprinkler heads within areas in which any painting is to take place. Remove covers upon completion of painting.
- E. Do not apply any field painting, including field touch-up, until after installation and testing is completed and system accepted.

3.05 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 00 00
PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. Provide new plumbing systems as indicated and in compliance with Contract Documents.
- B. The Work of this Section shall include all labor, materials, tools, equipment and appurtenances, and performing all operations necessary to furnish and install complete and operable systems in accordance with this Section of these Specifications, the Drawings, and the codes and standards listed herein.
- C. Coordinate with the Local Water Utility as to any Local restrictions or requirements relative to backflow prevention devices and metering.
- D. Limits of Work shall be as indicated on the Drawings. Items of Work shall consist of the following:
 - 1. All plumbing removals indicated.
 - 2. Domestic hot and cold-water piping to plumbing fixtures.
 - 3. Domestic tempered water piping to emergency eyewash/showers.
 - 4. Provide backflow preventers where indicated in domestic water piping for connection by other Sections to process equipment and hydronic heating systems
 - 5. Drain-waste-vent sanitary piping from plumbing fixtures and floor drains.
 - 6. Storm drain piping from roof drains.
 - 7. Domestic water heaters, electric water heaters, potable water well tanks, plumbing fixtures, roof drains, floor drains. Furnish roof drains to roofing trade for all roofs.
- E. Section includes:
 - 1. Piping materials and installation instructions common to most piping systems
 - a. Drain, Waste and Vent (DWV) piping
 - b. Domestic (Potable) Water Piping
 - c. Natural Gas Piping

2. Piping Accessories

- a. Valves, Valve Boxes, Strainers, Water Hammer Arresters, Trap Primers

3. Plumbing Equipment

- a. Backflow Prevention Assemblies
- b. Meters
- c. Circulation Pumps
- d. Expansion Tanks
- e. Water Heaters

4. Plumbing Fixtures

- a. (Accessible) Water Closets, (Accessible) Lavatories, Mop Sink Basins, Countertop Sinks, (Accessible) Electric Water Cooler and Drinking Fountains, Hose Bibbs, (Accessible) Combination Emergency Shower and Eyewash, Non-freeze Wall Hydrant, Trench Drains.
- b. Pipe Hangers and Supports
- c. Joining Materials
- d. Transition fittings
- e. Dielectric fittings
- f. Mechanical sleeve seals
- g. Sleeves
- h. Escutcheons
- i. Grout
- j. Drip Pans
- k. Access Panels

1.2 REFERENCES:

- A. Except as specified herein, the latest edition of the standards listed below form a part of this Specification to the extent referenced in this Section. Where earlier editions of

standards are adopted as referenced in applicable codes, those shall govern. The publications are referred to within the text by the basic designation only.

- B. In each of the standards referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears.
- C. Air-Conditioning And Refrigeration Institute (ARI):
 - 1. 1010: Self-Contained, Mechanically Refrigerated Drinking-Water Coolers
- D. American National Standards Institute (ANSI):
 - 1. Z21.10.1: Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 BTU Per Hour or Less
 - 2. Z21.10.3: Gas Water Heaters Vol. III, Storage Water Heaters with Input Ratings Above 75,000 BTU Per Hour, Circulating and Instantaneous
 - 3. Z21.22: Relief Valves for Hot Water Supply Systems
 - 4. Z358.1: Emergency Eyewash and Shower Equipment
- E. American Society Of Heating, Refrigerating And Air-Conditioning Engineers (ASHRAE):
 - 1. 90.1: Energy Standard for Buildings Except Low-Rose Residential Buildings
- F. American Society of Mechanical Engineers (ASME):
 - 1. A112.6.1: Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
 - 2. A112.18.1: Plumbing Fixture Fittings
 - 3. A112.19.2: Vitreous China Plumbing Fixtures
 - 4. A112.19.5: Trim for Water-Closet Bowls, Tanks and Urinals
 - 5. A112.21.1: Floor Drains
 - 6. A112.21.2: Roof Drains
 - 7. A112.36.2: Cleanouts
 - 8. B16.1: Cast Iron Pipe Flanges and Flanged Fittings
 - 9. B16.3: Malleable Iron Threaded Fittings

10. B16.12: Cast Iron Threaded Drainage Fittings
11. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings
12. B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
13. B16.23: Cast Copper Alloy Solder Joint Draining Fittings - DWV
14. B16.24: Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 900, 1500, and 2500
15. B16.26: Cast Copper Alloy Fittings for Flared Copper Tubes
16. B16.29: Wrought Copper and Wrought Copper Alloy Solder Joint Draining Fittings - DWV
17. B16.32: Cast Copper Alloy Joint Fittings for Solvent Draining Systems
18. B16.50: Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
19. B40.1: Pressure Gauges and Gauge Attachments

G. American Society of Sanitary Engineering (ASSE):

1. 1003: Water Pressure Reducing Valves
2. 1013: Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers
3. 1015: Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies
4. 1017: Temperature Actuated Mixing Valves for Hot Water Distribution Systems
5. 1018: Trap Seal Primer Valves - Potable, Water Supplied
6. 1019: Vacuum Breaker Wall Hydrants, Freeze Resistant, Automatic Draining Type
7. 1071: Temperature Actuated Mixing Valves for Plumbed Emergency Equipment

H. ASTM International (ASTM):

1. A47: Ferritic Malleable Iron Castings
2. A53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. A74: Cast Iron Soil Pipe and Fittings
4. A126: Gray Iron Castings for Valves, Flanges and Pipe Fittings

5. A183: Carbon Steel Track Bolts and Nuts
6. A518: Corrosion-Resistant High-Silicon Iron Castings
7. A536: Ductile Iron Castings
8. B32: Solder Metal
9. B42: Seamless Copper Pipe, Standard Sizes
10. B88: Seamless Copper Water Tube
11. B306: Copper Drainage Tube (DWV)
12. B584: Copper Alloy Sand Castings for General Applications
13. C564: Rubber Gaskets for Cast Iron Soil Pipe and Fittings
14. D2000: Rubber Products in Automotive Applications
15. E72: Standard Test Methods of Conducting Strength Tests of Panels for Building Construction
16. E455: Standard Test Method for Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings
17. E564: Standard Practice for Static Load Test for Shear Resistance of Framed Walls for Buildings

I. American Water Works Association (AWWA):

1. C104: Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
2. C105: Polyethylene Encasement for Ductile-Iron Pipe Systems
3. C110: Ductile-Iron and Gray-Iron Fittings, 3 In. through 48 In., for Water
4. C111: Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
5. C115: Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
6. C151: Ductile-Iron Pipe, Centrifugally Cast, for Water
7. C500: Metal-Seated Gate Valves for Water Supply Service
8. C509: Resilient-Seated Gate Valves for Water Supply Service
9. C651: Disinfecting Water Mains

10. C700: Cold-Water meters – Displacement Type, Bronze Main Case
 11. C701: Cold-Water Meters-Turbine Type, for Customer Service
 12. C702: Cold-Water meters – Compound Type
 13. C707: Encoder Type, Remote Registration Systems for Cold-Water Meters
 14. D100: Welded Steel Tanks for Water Storage
- J. American Welding Society (AWS):
1. A5.8: Filler Metals for Brazing and Braze Welding
 2. BRH: Brazing Handbook
- K. Cast Iron Soil Pipe Institute (CISPI):
1. 301: Hubless Cast Iron Soil Pipe and Fittings for Sanitary Waste and Vent Piping Applications
 2. 310: Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary Drain, Waste, and Vent Piping Applications
 3. HSN-85: Neoprene Rubber Gaskets for Hub and Spigot Cast Iron Soil Pipe and Fittings
- L. Foundation For Cross-Connection Control And Hydraulic Research (FCCCHR):
1. FCCCHR List: List of Approved Backflow Prevention Assemblies
- M. Institute of Electrical and Electronic Engineers (IEEE):
1. C37.90.1: Sure Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
- N. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):
1. SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation
 2. SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
 3. SP-71: Gray Iron Swing Check Valves, Flanged and Threaded Ends
 4. SP-80: Bronze Gate, Globe, Angle and Check Valves
 5. SP-85: Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

6. SP-110: Ball Valves Threaded, Socket Welding, Solder Joints, Grooved and Flared Ends
- O. National Sanitation Foundation (NSF):
 1. 61: Drinking Water System Components
- P. Plumbing and Drainage Institute (PDI):
 1. G 101: Testing and Rating Procedure for Grease Interceptors with Appendix of Sizing and Installation Data
 2. WH 201: Water Hammer Arresters
- Q. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
 1. SMACNA Seismic Restraint Unit: Seismic Restraint Manual: Guidelines for Mechanical Systems
- R. Underwriters Laboratories (UL):
 1. 430: Waste Disposers
 2. 795: Commercial-Industrial Gas Heating Equipment
 3. 1453: Electric Booster and Commercial Storage Tank Water Heaters
- 1.3 DEFINITIONS:
 - A. The following phrases shall have the following meanings for the purposes of the Work of this Section:
 1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
 2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
 3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
 4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
 5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.
3. "Domestic water" shall mean potable drinking water.
4. "Tempered water" shall mean domestic water heated between 60 and 100 degrees F.
5. "Drain" piping shall mean sanitary drain piping. Refer to Section 22 14 13 for Storm Drain Piping.

1.4 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00:

1. Shop Drawings:
 - a. Coordination Drawings - Prepare as specified in Paragraph "Cooperation and Coordination with Other Trades" of this Section.
 - b. Backflow preventers - Submit a layout drawing indicating the location of all backflow preventers to the Utah Department of Environmental Protection (DEP) for their approval prior to submitting to the Engineer.
2. Product Data: For each product, provide descriptive data to show the specific manufacturer, model, type, size, capacity, curves, wiring diagrams, options, etc. of each item. Where products are available with Energy Star labeling, they shall be provided
3. Certification - Submit documentation certifying completion of the following items in compliance with this Section.
 - a. Tests
 - b. Flushing
 - c. Manufacturers' services.
 - d. Disinfection
4. Test Reports - prepare as specified in Part 3 of this Section
 - a. Pressure tests
 - b. Backflow preventer tests
 - c. Functional testing

5. Certificates and Licenses - Prepare as specified in Part 1 of this Section.
 - a. Qualifications of Installer
 - b. Qualifications of Construction Supervisor
 6. Operation and Maintenance Manuals - Prepare manuals in accordance with Section 01 78 23.
 7. Closeout Submittals
 - a. Record Drawings - Prepare as specified in Part 1 of this Section.
 - B. Welding certificates.
- 1.5 QUALITY ASSURANCE:
- A. Provide in accordance with Section 01 43 00.
 - B. Provisions:
 1. Drawings and specification direct attention to certain features of equipment, but do not purport to cover all details entering into design and construction of the equipment, controls, or appurtenances.
 2. Consideration shall be given only to products of manufacturers who demonstrate successful experience in manufacture, operation, and servicing equipment of type, size, performance, and reliability equal to that specified. Equipment and components shall be the product of a single manufacturer insofar as possible.
 3. Equipment furnished to fit within the space allocated with adequate clearance for proper operation and maintenance.
 - C. Workmanship and Design:
 1. Provide equipment such that all parts are designed for continuous and uninterrupted service, and such that lubrication, adjustment, or replacement of parts is possible without manufacturer's assistance. Corresponding parts of multiple units shall be interchangeable.
 2. Install equipment that complies with state, local and federal codes and regulations.
 - D. Alternate Equipment and Arrangement:
 1. If any equipment submitted for acceptance requires arrangement differing from that indicated or specified, Contractor to prepare and submit for review, detailed structural, mechanical and electrical drawings, and equipment lists showing all necessary changes and all special features of equipment proposed. Changes are at no additional compensation to the Contractor.

E. Qualifications of Installer:

1. Prior to installation, submit data showing the name and license of the installing contractor and that he has successfully installed systems of the same type and design as specified herein. Data shall include names and locations of at least two installations of such systems. Indicate type and design of each system and certify that each system has performed satisfactorily in the manner intended for not less than 18 months. The installing contractor shall be licensed to perform applicable plumbing systems installation in the state in which the project is located.

F. Qualifications of Construction Supervisor:

1. Provide a Construction Supervisor with a minimum of 5 years of experience in plumbing construction supervision who shall be responsible for the installation of the Work of this Section of the Specifications. The Construction Supervisor shall be licensed to perform applicable plumbing systems supervision in the state in which the project is located. Prior to installation, submit data for acceptance showing the name and license of the Construction Supervisor.

G. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

H. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

I. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

J. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE AND HANDLING:

A. Provide in accordance with Section 01 66 10 and as specified.

B. Shipping:

1. Equipment, material and spare parts are to be shipped completely assembled except where partial disassembly is required by transportation regulations or for protection of components.

C. Receiving:

1. Inspect and inventory items upon delivery to site.

2. Store and safeguard equipment, material and spare parts in accordance with manufacturer's recommendations.
3. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
4. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 SPECIAL REQUIREMENTS:

A. Refer to applicable sections of Division 1 with regard to providing the following:

1. Submittal of manufacturer's specifications, catalog data, descriptive matter, illustrations, diagrams, etc., including complete motor data for all equipment
2. Nameplates
3. Foundations, installations, and grouting
4. Operating and maintenance instructions and parts lists
5. Lubricants
6. Special tools
7. Bolts, anchor bolts, and nuts
8. Concrete inserts
9. Sleeves
10. Electric motors
11. Voltage rating of motors
12. Equipment drive guards

1.8 COORDINATION:

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces.

- D. The Contractor shall coordinate with Owner for all new to existing connections, system shutdowns and restart-up.

1.9 COOPERATION AND COORDINATION WITH OTHER TRADES:

- A. Work shall be performed in cooperation with other trades on the project and so scheduled as to allow efficient completion of the project. Materials and equipment shall be installed as fast as conditions permit and installed properly.
- B. Furnish to all other trades advance information on location and size of all concrete pads, chases, frames, boxes, pits, sleeves, and openings needed for the Work, and also furnish layout information and shop drawings necessary to permit other trades affected by the Work to install their work properly coordinated and without delay.
- C. Where there is evidence that Work installed interferes with the work of other Sections, assist in working out space conditions to make satisfactory adjustments.
- D. With the acceptance of the Engineer and without extra cost to the Owner, make reasonable modifications in Work specified under this Section required to coordinate with normal structural interferences, or for proper execution of specified work.
- E. If work is installed before coordinating with other trades to cause interference with the work of such trades, make all necessary changes in Work under this Section of the at no additional cost to the Owner.
- F. Protect all materials and work of other trades from damage that may be caused by the Work required under this Section and be responsible for repairing any damages caused by such work without any additional cost to the Owner.
- G. Follow Drawings in layout work. Check drawings of, and coordinate with, other trades to verify special provisions, installation requirements and spaces in which Work provided under this Section will be installed. Maintain maximum headroom or space conditions at all points. Where headroom or space conditions appear inadequate, notify the Engineer before proceeding.
- H. Attend regular coordination and job progress meetings required.

1.10 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION:

- A. All electrical apparatus and controls associated with equipment installed under this Section but which are not integral with the equipment served, will be furnished under Division 26. All mounting and wiring of non-integral electrical apparatus and controls, and interconnecting wiring to equipment served will be done under Division 26. All electrical apparatus associated with equipment installed under this Section which are integral with the equipment served, will be field wired under Division 26.
- B. Access panels shall be furnished under this Section and installed by the trade responsible for the appropriate Section of the Specifications for the surface upon which the panels

are mounted. Prepare a schedule showing location, size and function of all required access panels and deliver schedule to representatives of all installing trades.

- C. Prefabricated flashing for plumbing vents, and roof drains shall be furnished under this Section.
 - D. Anchoring inserts shall be furnished under this Section and installed under Section 03 15 20. Prepare a schedule showing location, size and function of all required anchoring inserts and deliver schedule to representative of the installing trade.
 - E. Pipe sleeves shall be furnished under this Section and installed by the trade whose finished interior surfaces will be penetrated. Prepare a schedule showing location, size and function of all required pipe sleeves and deliver schedule to representatives of all installing trades.
- 1.11 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION:
- A. Water meters will be furnished by the Local Water Utility and shall be installed under this Section.
- 1.12 ELECTRICAL WORK:
- A. All electrical apparatus and controls associated with equipment installed under this Section but which are not integral with the equipment served, will be furnished under Division 26. All mounting and wiring of non-integral electrical apparatus and controls, and interconnecting wiring to equipment served will be done under Division 26. All electrical apparatus associated with equipment installed under this Section which are integral with the equipment served, will be field wired under Division 26.
 - B. All equipment furnished under this Section requiring motors shall have motors factory furnished and installed by the manufacturer of the equipment served and shall be mounted and aligned so as to run free and true. Provide internal wiring and motors for equipment as an integral part of the equipment. Disconnect switches, motor starters and contactors will be furnished, installed and wired by Division 26.
 - C. When motors and other associated electrical apparatus furnished are larger than sizes indicated on the Drawings, the cost of additional electrical service and related work shall be included under the Section that furnished that motor.
- 1.13 CODES, PERMITS AND FEES:
- A. Except for additional requirements as specified or indicated under the Work of this Section, materials, workmanship and equipment shall conform with the governing edition of the following regulations, and agency requirements. In the Plumbing Code referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears.

1. State and Local Building Codes, including but not limited to, the Utah Plumbing Code, the Utah Energy Conservation Code, and Utah Building Code.
2. Utah Department of Environmental Protection.
3. Local Fire Department
4. Local Water and Sewer Authority or Department
5. Occupational Safety and Health Administration (OSHA)
6. Any other local codes or requirements of Authorities Having Jurisdiction.

- B. Pay for all fees and give all notices, file all plans, obtain all permits and licenses, and obtain all necessary approvals from Authorities Having Jurisdiction. Deliver all certificates of inspection to the Authorities Having Jurisdiction. No work shall be covered before examination and approval by Authorities Having Jurisdiction. Replace imperfect or condemned work to conform to inspectional requirements, satisfactory to the Owner, Engineer and Authorities Having Jurisdiction without extra cost to the Owner. If Work is covered before inspection and acceptance, pay costs of uncovering and reinstalling the covering, whether it meets contract requirements or not.

1.14 RECORD DRAWINGS:

- A. Record Drawings shall be provided under this Section in accordance with Division 00 requirements and as specified herein.
- B. As work progresses and for the duration of the Contract, maintain a complete and separate set of prints of Drawings at the job site at all times. On a daily basis, record work completed and all changes from original Drawings clearly and accurately, including work installed as a modification or addition to the original design such as change orders, instructions issued by the Engineer, or conditions encountered in the field. In addition, take photographs of all concealed equipment in gypsum board ceilings, shafts, underground (buried) piping routes and supports and other concealed, inaccessible work. At completion of work, make copies of photographs with written explanation on back. These shall become part of Record Drawings.
- C. Record Drawings shall show as-built condition of pipe routing and sizes, valve locations, details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer and make and model numbers of final equipment installation. Remove all superseded data to show the completed work. Accurately indicate the location, size, type, and elevation of new buried piping and their relationship to existing buried piping.
- D. The Record Drawings will be used as a guide for determining the progress of the Work installed. They shall be inspected on a regular basis and shall be corrected immediately if found inaccurate or incomplete. Requisitions for payment will not be acted upon until the Record Drawings are accurate and up-to-date.

- E. At completion of Work prepare a complete set of cad-drafted Record Drawings showing all systems as actually installed. The Contract Drawing electronic CAD files will be made available for this Subcontractor's use to serve as backgrounds for the Record Drawings. Provide all drawings necessary to show the required record information. Submit mylars and three sets of cad-drafted prints to the Engineer for comments as to compliance with this Section. Make all modifications so noted by the Engineer
 - F. Certify the accuracy of the Record Drawings. Record Drawings shall become the property of the Owner.
 - G. When required by jurisdiction, submit the record set for approval by the Authority Having Jurisdiction in a form acceptable to the jurisdiction.
- 1.15 PERFORMANCE REQUIREMENTS – GENERAL:
- A. Piping Systems – Common Requirements:
 - 1. Install piping according to the following requirements and Division 22 sections specifying piping systems.
 - 2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, equipment sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
 - 3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
 - 4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 - 5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.
 - 6. Install piping to permit valve servicing.
 - 7. Install piping at indicated slopes.
 - 8. Install piping free of sags and bends.
 - 9. Install fittings for changes in direction and branch connections.
 - 10. Install piping to allow application of insulation.
 - 11. Select system components with pressure rating equal to or greater than system operating pressure.

12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
13. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type with polished chrome-plated finish.
 - b. Chrome-Plated Piping: One-piece, cast-brass or stamped steel type with polished chrome-plated finish.
 - c. Insulated Piping at Wall and Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or stamped-steel type with polished chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or stamped steel type with polished chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or stamped steel type with polished chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or stamped steel type with polished chrome-plated finish.
14. Sleeves are not required for core-drilled holes.
15. Permanent sleeves are not required for holes formed by removable PE sleeves.
16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, concrete floors, and roof slabs.
17. Cut sleeves to length for mounting flush with both surfaces.
 - g. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
18. Install sleeves in new walls and slabs as new walls and slabs are constructed.
19. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
 - b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

- c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.

- (1) Seal space outside of sleeve fittings with grout.

- 20. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07 92 00 for materials and installation.
- 21. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - b. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 - c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- 22. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- 23. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 00 for materials.
- 24. Verify final equipment locations for roughing-in.
- 25. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

B. Piping Joint Construction:

1. Join pipe and fittings according to the following requirements and Division 22 sections specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.
 - a. Plain-End Pipe and Fittings: Use butt fusion
 - b. Plain-End Pipe and Socket Fittings: Use socket fusion
10. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

C. Transition Fittings:

1. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

2. Manufacturers:
3. Cascade Waterworks Mfg. Co. (Special order required)
4. Dresser Industries, Inc.; DMD Division (Special order required)
5. Ford Meter Box Company, Incorporated (The); Pipe Products Division (Special order required)
6. JCM Industries (Special order required)
7. Smith-Blair, Inc. (Special order required)
8. Viking Johnson (Dewatering only)
9. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
10. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
11. Aboveground Pressure Piping: Pipe fitting.

D. Piping Connections:

1. Make connections according to the following, unless otherwise indicated:
 - a. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - b. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - c. Dry Piping Systems: Install dielectric coupling and flanges to connect piping materials of dissimilar metals.
 - d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

E. Equipment Installation – Common Requirements:

1. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
3. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

4. Install equipment to allow right of way for piping installed at required slope.

F. Painting:

1. Painting of plumbing systems, equipment, and components is specified in Division 09.
2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

G. Concrete Bases:

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - a. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - g. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03.

H. Supports and Anchorages:

1. Erection of Metal Supports and Anchorages:
 - a. Refer to Division 05 for structural steel.
 - b. Refer to painting requirements as specified in Division 09 sections.

- c. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- d. Field Welding: Comply with AWS D1.1.

2. Erection of Wood Supports and Anchorages:

- a. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
- b. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- c. Attach to substrates as required to support applied loads.
- d. All wood products shall be treated to be fire resistant.

I. Grouting:

- 1. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- 2. Clean surfaces that will come into contact with grout.
- 3. Provide forms as required for placement of grout.
- 4. Avoid air entrapment during placement of grout.
- 5. Place grout, completely filling equipment bases.
- 6. Place grout on concrete bases and provide smooth bearing surface for equipment.
- 7. Place grout around anchors.
- 8. Cure placed grout.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Where applicable, all products requiring approval by the State Department of Public Safety shall be so approved. Where product types are available with Energy Star labeling, they shall be provided.

- B. All potable water piping components shall comply with NSF 61 test standards via third-party testing and certification. Potable water piping components under the jurisdiction of the Federal Reduction of Lead in Drinking Water Act shall comply with NSF 372 test standards via third-party testing and certification.

2.2 DRAIN, WASTE AND VENT (DWV) PIPING:

- A. Fittings shall be long radius fittings, except fittings in vent piping may be short radius fittings. Minimum size piping shall be 2 inch (50 mm) for buried piping and 1-1/2 inch (40 mm) for aboveground piping.

- B. Buried Piping:

- 1. Cast-Iron Hubless Pipe and Fittings:

- a. CISPI 301, with CISPI 310 couplings composed of rubber sleeves and corrugated stainless steel bands and tightening devices.

- 2. Cast-Iron Hub and Spigot Pipe and Fittings:

- a. ASTM A74 with ASTM C564 or CISPI HSN-85 rubber compression gasket joints, service weight.

- 3. Copper Tubing (for Trap Primer Piping Only):

- a. ASTM B88, Type L, soft annealed copper tubing with brass compression fittings at connections to trap primer device and fixture trap. Provide minimum number of intermediate joints in buried copper tubing. For intermediate joints, provide ANSI B16.18 or ASME B16.22 solder joint fittings.

- (1) Intermediate joints shall be brazed. Brazing filler metal shall conform to AWS A5.8, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints. Braze joint fittings shall be specifically designed for brazing.

- (2) Where copper tubing is indicated to be embedded in concrete, sleeve the entire length of embedded copper tubing with flexible low density polyethylene tubing. Sleeving shall be minimum two sizes larger than the copper tubing.

- C. Aboveground Piping:

- 1. Cast-Iron Hubless Pipe and Fittings for Piping 1-1/2 inch (40 mm) and Larger:

- a. CISPI 301, with CISPI 310 couplings composed of rubber sleeves and corrugated stainless steel bands and tightening devices.

2. Copper Tubing for Piping 2 inch (50 mm) and Smaller:
 - a. ASTM B306, with ANSI B16.23, ASME B16.29, or ASME B16.32 solder joint fittings using ASTM B32, 95-5 tin-antimony or Grade Sn96 tin-silver solder, and flux containing not more than 0.2 percent lead.
3. Grooved-End Steel Piping (for Roof Drainage Only):
 - a. ASTM A53, Schedule 40, hot-dip galvanized, cut grooved-end steel pipe; ASTM A47 or ASTM A536, hot-dip galvanized, grooved-end fittings, and mechanical couplings; ASTM A183 coupling nuts and bolts; ASTM D2000 rubber gaskets for water service. Fittings, mechanical couplings, and rubber gaskets shall be supplied by the same manufacturer.
4. Galvanized Steel Pipe (for Equipment Drainage Only):
 - a. ASTM A53, hot-dipped galvanized steel pipe, Schedule 40 with ASME B16.12 galvanized cast iron threaded drainage fittings.
5. Sump Pump Discharge and Sewage Ejector Discharge:
 - a. For sizes 2-inch (50 mm) and smaller: ASTM B88, Type L, hard drawn copper tubing with ANSI B16.18 or ASME B16.22 solder joint fittings. Provide ASTM B42 copper pipe nipples with threaded end connections. Provide ASTM B32, 95-5 tin-antimony solder, or provide Plumbing Code approved lead-free solder.

D. Cleanouts:

1. ANSI A112.36.2M; provide threaded bronze cleanout plugs.
2. Floor Cleanouts:
 - a. Provide coated cast-iron or ductile-iron floor cleanout with flange; threaded outlet; adjustable height polished bronze, nickel bronze, stainless steel, or chromium-plated copper alloy top and scoriated floor plate with "CO" cast in the plate; and countersunk screws for installing floor plate flush with finished floor.
3. Wall Cleanouts:
 - a. Provide threaded bronze cleanout plugs and polished stainless steel or chromium-plated copper alloy cover plate and secure to cleanout plug with countersunk stainless steel screw.
4. Cleanouts Exterior to Buildings:

- a. Provide cast-iron cleanouts and countersunk plugs. Provide cleanouts flush with finished grade or concrete slab.

E. Drains:

1. ASME A112.21.1M unless otherwise specified; coated cast-iron or ductile-iron drains with membrane clamp rings for use with membrane waterproofing.
2. Floor Drains:
 - a. Provide with double drainage flange; threaded adjustable round top with cast bronze, nickel bronze polished stainless steel, or chromium-plated copper alloy strainer; non-puncturing flashing collar with weep holes; 1/2-3/4 inch (15-20 mm) trap primer connection; and bottom outlet to suit specified piping. Drains of sizes 2, 3, and 4 inch (50 80, and 100 mm) shall have strainers with minimum free drainage area of 5, 11, and 18 square inches (3,226, 7,097, and 11,613 mm), respectively.
 - b. Provide 4" funnel equipped strainer where called for on the Contract Drawings.
 - c. Provide deep seal P-traps for each floor drain. (P-traps not required upstream of drain sump in High Service Pump Station.)
3. Roof Drains:
 - a. ASME A112.21.2M; furnish hot-dip galvanized cast-iron or ductile-iron drains, with minimum of 10 inch (250 mm) diameter body, non-puncturing flashing clamp device with integral gravel stop and deck clamp, and removable cast-iron or ductile-iron or polypropylene locking dome. Free area of dome shall be not less than two times the free area of drain outlet. Coordinate with installing trade to install drain flashing ring seat flush with adjacent roof deck, and secure rigidly in place with deck clamp. Provide 4-lb (1.55 mm thick) sheet lead flashing.
 - b. Downspout nozzles shall be cast bronze units with loose wall flange and threaded connection, Josam Mfg. Co., No. 25010; Wade Inc., No. W-3940; Zurn Industries, Inc., No. Z-199; or acceptable equivalent product.
4. Floor Sinks (Drains):
 - a. Provide cast-iron body with white acid-resisting porcelain enameled or epoxy interior, double drainage flange, nickel bronze rim and slotted grate, removable stainless steel or aluminum slotted buckets, and deep seal P-trap.
5. Air Gap Drains:

- a. Air gap drain shall provide unobstructed physical separation between the discharge end of a potable water connection and drainage facilities.
- b. Air gap drain shall be bronze or cast iron.
- c. Manufacturer:
 - (1) Watts

F. Backwater Valves:

- 1. Ball float type, galvanized cast iron body, ball float with copper alloy bushing and replaceable neoprene seat, threaded or no-hub inlet by no-hub outlet.

2.3 DOMESTIC WATER PIPING AND SERVICE WATER PIPING:

A. Buried Piping:

- 1. Copper Tubing for Piping 2 inch (50 mm) and Smaller:
 - a. ASTM B88, Type K, soft annealed copper tubing with ASME B16.50 brazed joint fittings. Provide minimum number of joints in buried copper tubing.
 - (1) Joints shall be brazed. Brazing filler metal shall conform to AWS A5.8, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.
- 2. Copper Tubing for Piping 3 inch (80 mm) and Smaller
 - a. ASTM B88, Type K, hard drawn copper tubing with ASME B16.50 braze joint fittings; or with ASME B16.26 flared joint fittings. Provide minimum number of joints in buried copper tubing.
 - (1) Joints shall be brazed. Brazing filler metal shall conform to AWS A5.8, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.
- 3. Ductile-Iron Piping for piping 4 inch (100 mm) and Larger
 - a. AWWA C151 ductile-iron pipe, outside coated, AWWA C104 cement mortar lined, AWWA C111 rubber gasket joints, and AWWA C110 fittings. Provide concrete thrust blocks at the elbow where the buried piping turns up toward the floor, and restrain the pipe riser with steel rods from the elbow to the flange above the floor. Aboveground piping shall have flanged end connections conforming to AWWA C115 for flanged pipe and AWWA C110 for flanged fittings.
- 4. Trap Primer Piping:

- a. ASTM F876/877, NSF 14 and 61, cross-linked polyethylene tubing with oxygen diffusion barrier, minimum 150 psig (1,034 kpag) and minimum 180 degree F (82 degrees C) rated, compression fitting or mechanical insert fitting joints. Provide minimum number of joints in embedded tubing.

B. Aboveground Piping:

1. Copper Tubing:

- a. ASTM B88, Type L, hard drawn copper tubing with ANSI B16.18 or ASME B16.22 solder joint fittings; or with ASME B16.26 flared joint fittings. Provide ASTM B42 copper pipe nipples with threaded end connections. Provide ASTM B32, 95-5 tin-antimony solder, or provide Plumbing Code approved lead-free solder.

C. Flanges:

1. ASME B16.22 or ANSI B16.24 for use in copper tubing.

2. Flange Accessories:

- a. Gaskets: Provide one piece, factory cut, 1/16 inch (2 mm) thick, synthetic rubber gaskets suitable for use with potable water. Gaskets shall be rated for 32 to 180 degrees F (0 to 82 degrees C) service temperature. Provide full-face gaskets for flat-face flanged joints, and ring gaskets for raised-face flanged joints. Dimensions for gaskets shall be in accordance with ASME B16.21.
- b. Bolting: Material for bolts and studs ASTM A307, Grade-B and for nuts ASTM A194/A194M, Grade-2. Dimensions of bolts, studs and nuts ANSI B18.2.1 and ASME B18.2.2 with threads conforming to ASME B1.1 coarse type, with Class 2A fit for bolts and studs, and Class 2B for nuts.

D. Valves:

- 1. Provide valves suitable for minimum of 125 psig (862 kpag) and minimum of 180 degrees F (82 degrees C) hot water. Valves shall have flanged end connections, except sizes smaller than 2-1/2 inch may have threaded end connections with a union on all but one side of the valve, or solder end connections for connections between bronze valves and copper tubing. For gate, globe and angle valves, provide blue finish, and red finish on handwheels for valves in domestic cold water piping, and domestic hot water piping respectively. Ball valves may be provided in lieu of gate valves.
- 2. Gate Valves (3 inch (80 mm) and Smaller):
 - a. MSS SP-80, Class 125 bronze valves

3. Gate Valves (4 inch (100 mm) and Larger):
 - a. AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to:
 - (1) AWWA C500 shall be outside-screw-and-yoke rising-stem type with double-disc gates and flanged ends,
 - (2) AWWA C509 shall be outside-screw-and-yoke rising-stem type with flanged ends, and
 - (3) UL 262 shall be outside-screw-and-yoke type, shall have double-disc or split-wedge type gate and flanged ends, and shall be designed for a hydraulic working pressure of 125 psi. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Provide valves with handwheels that open by counterclockwise rotation of the valve stem. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. In lieu of flanged ends, valves may have grooved ends suitable for grooved type joints, as specified in paragraph entitled "Ductile-Iron Piping." Valves shall have gearing and indicator, AWWA C500. Provide valve with bypasses, AWWA C500. Valves shall be of one manufacturer.
4. Check Valves:
 - a. MSS SP-80, Class 125, swing check, except sizes 2-1/2 inch (65 mm) and larger shall conform to MSS SP-71, Class 125, swing check, cast-iron or bronze body.
5. Ball Valves:
 - a. MSS SP-110, full port design, copper alloy, except sizes 2-1/2 inch (65 mm) and larger shall be ductile-iron body or cast-iron body. Valves shall have lever handles, stainless steel ball and PTFE seats and seals.
6. Safety Relief Valves:
 - a. Combination Pressure and Temperature Relief Valves: ANSI Z21.22 copper alloy body, automatic reseating, test lever, and discharge capacity based on AGA temperature steam rating.
 - b. Pressure Relief Valves: ANSI Z21.22 copper alloy body, automatic reseating with test lever.
7. Vacuum Relief Valve (for Water Heater):

- a. ANSI Z21.22 rated and CSA certified, copper alloy body with an integral protective cover, 15 psig (103 kpag) WSP. Valve may be vertical or horizontal mounting type.
8. Water Temperature Regulating Valves:
- a. Copper alloy or cast-iron body valve with adjustable range thermostat to allow settings between 110 (43) and 160 degrees F (71 degrees C).
9. Mixing Valves:
- a. General: Factory assembled and tested, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an acceptable type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Valves shall have 125 psig (862 kpag) minimum rated inlet pressure.
 - b. Emergency Eyewash/Shower Mixing Valves: ASSE 1071, ANSI Z358.1. Mixing valve shall control and maintain the temperature of the tempered water to plus/minus 3 degrees F (2 degrees C). Unit shall be self-contained and include a thermostatic water mixing valve with adjustable high temperature limit stop factory set for 90 degrees F (32 degrees C), union angle checkstops on the inlets, top or bottom inlets and top outlet, bypass inlet, wall mounting bracket, and all piping and fittings for a complete unit. Unit shall be able to be set to the correct temperature for the specific contaminant but locked in place to prevent changing of the temperature by accident; unit shall be factory set for 85 degrees F (27 degrees C) outlet temperature. Unit shall be able to flow a minimum of 30 gpm (114 l/m) at 30 psig (207 kpag). Unit shall close down upon failure of cold water supply and include cold water bypass capable of 40 gpm (151 l/m) at 30 psig (207 kpag) upon failure of hot water supply. Unit shall have temperature override protection via a redundant thermostatic control valve on the outlet that opens on temperature rise above 90 degrees F (32 degrees C) to introduce cold water and maintain tepid flow. Valves shall have rough bronze finish.
 - (1) Valves shall have rough bronze finish without plating, and a dial thermometer on the inlet thermometers, and shall be mounted in a recessed stainless-steel cabinet].
 - c. All Other Mixing Valves: ASSE 1017; adjustable high temperature limit stop factory set for 120 degrees F (49 degrees C). Mixing valves shall maintain water temperature within 5 degrees F (3 degrees C) of any setting.

Unit shall be able to flow a minimum of 1.0 gpm (3.8 l/m) at 30 psig (207 kpag). Valves shall have integral wall support and cast lever handle.

- (1) Valves shall have rough bronze finish without plating and test connections.

10. Water Pressure Reducing Valves:

- a. ASSE 1003; non-sticking rolling diaphragm design; bronze body, replaceable stainless steel seat and elastomer disc, union connection, and integral stainless steel strainer; pressure gauge tapping; integral thermal expansion bypass to permit flow of water back through the valve into the main when pressure due to thermal expansion on the outlet side of valve exceeds the pressure in the main; minimum 35 to 150 degree F (2 to 66 degrees C) operating temperature, 150 psi (1,034 kpa) minimum rated inlet pressure, 25 to 75 psig (172 to 517 kpag) adjustable outlet pressure. Parts shall be serviceable without removing the valve from the line.
- b. Valve shall be rated for 0 to 90 gpm (0 to 341 l/m) minimum.

11. Trap Primer Valves:

- a. ASSE 1018 automatic trap primers; all bronze body with integral vacuum breaker, non-liming internal operating assembly, and gasketed bronze cover; plain finish.

12. Solenoid Valves:

- a. Electric solenoid valves designed to operate on 120 VAC, single phase power, normally open or normally closed as indicated. Solenoid valves shall be packless, direct acting with cushioned closing and have an epoxy-resin molded waterproof coil. Valves shall have copper alloy body for use in potable water applications and be rated for 150 psig.

E. Water Meters:

1. General: NSF 61 certified, minimum 150 psig rated operating pressure and 35 to 100 degree F operating temperature, with registration measuring in U.S. gallons or cubic feet as required by the local water authority. Meter cases shall be no-lead copper alloy. Meter cases constructed of plastic shall not be accepted. Provide direct reading register at each meter. Register boxes and register box lids shall be bronze or an approved plastic material. Meters shall be designed for easy removal of all interior parts without disturbing the connections to the pipeline. The manufacturer, model, and serial number shall be marked permanently on both meter casings and registers. Size and direction of flow through the meter shall be marked permanently on all meters. Provide strainer integral with meter or separate plate type strainer. Provide remote reading registration.

2. Meters 3/4-Inch to 2-1/2Inch Size: AWWA C700, positive displacement type with nutating disc, magnetic drive, and sealed register. No oscillating-piston style meters will be accepted.
3. Meters 3-Inch to 6-Inch Size: AWWA C702, compound meters consisting of a combination of a main-line meter of the turbine type for measuring high rates of flow and a disc type meter for measuring low rates of flow. Turbine meter shall be in-line, horizontal-axis, high-velocity type with AWWA Class II turbine measuring element. Disc meter shall be positive displacement type with nutating disc and magnetic drive. No oscillating-piston style meters will be accepted. The compound meter shall have an automatic valve mechanism for diverting low rates of flow through the bypass meter. Both metering devices with sealed registers shall be contained in the same case.
4. Registers: Registers shall provide at least six-digit visual registration. The measuring units shall be printed on the face of the register. The register shall have a full test sweep hand or dial. All registers shall be removable without disassembly of the meter or depressurizing the service line. The register shall be free of openings to protect the internal electronics of the register. Lens covers shall be made of polycarbonate or other suitable engineering polymer for indoor installations and mineral glass for underground pit installations.
5. Plate Strainers: AWWA C702. All strainers provided shall have top access without blow down ports. Cases shall be bronze. Strainer plates shall be 18-8 stainless steel or bronze.
6. Remote Registration Requirements:
 - a. Meters shall have encoder-type remote-registration conforming to AWWA C707. Registers using generator pulses or low voltage conversions shall not be permitted. Power requirement for data transmission shall be supplied by an interrogation device. Registers shall be compatible with various brands of interrogation equipment. The register shall, in a digital format, simultaneously encode at least six significant digits of the meter reading for transmission through the remotely located receptacle. A meter identification number shall also be provided with each reading.

F. Strainers:

1. Strainers shall have blow off outlet with pipe nipple and gate valve or ball valve with discharge pipe nipple. Copper alloy or cast-iron body. Provide stainless steel strainer element with perforations of 0.047 inch (1.2 mm).

G. Pressure Gauges:

1. Pressure gauges shall be ASME B40.1, liquid filled, 1 percent accuracy or better, with bronze bourdon tube and steel or brass case, as manufactured by U.S. Gauge American, Mueller, Trerice, Ashcroft or acceptable equivalent product.

2. Gauges shall have a minimum 3 inch (80 mm) diameter face. Dial gradations reading in "PSIG" (kpag) shall be such that the normal operating pressure of the system installed shall be indicated in middle 1/3 of the scale range.
3. Gauges shall be equipped with a ball valve shutoff and snubber. An outlet, at least 1/4-inch (8 mm) size, plugged for the installation of the inspector's gauge shall be located between each valve and gauge.

H. Thermometers:

1. Bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; minimum 3 inch (80 mm) diameter dial with glass face gasketed within the case; accuracy within 2 percent of scale range. Dial gradation reading in "Degrees Fahrenheit" shall be such that the normal operating temperature is in middle 1/3 of scale range.

I. Dielectric Connections:

1. Provide at connections between copper and ferrous metal piping materials. ASTM F441, Schedule 80, 4 inch (100 mm) minimum length, may be provided for dielectric connections in pipe sizes 2 inch (50 mm) and smaller.

J. Water Hammer Arresters:

1. PDI WH 201, hydropneumatic cushion with stainless steel bellows.

K. Valve Boxes:

1. For each buried valve provide cast-iron, ductile-iron, or plastic box of a suitable size. Provide cast-iron, ductile-iron, or plastic cover respectively for the box with the word "WATER" cast on the cover. Plastic boxes shall be constructed of ABS plastic or inorganic fiber-reinforced black polyolefin plastic. Coat cast-iron and ductile-iron boxes with bituminous paint.

L. Backflow Preventers:

1. Provide double check backflow preventer with gate or ball valve on both ends and inlet strainer. Backflow preventers shall have replaceable seats and discs, bronze body, rated for minimum 35 to 150 degrees F (2 to 66 degrees C) and 175 psig (1,207 kpag). Backflow prevention assemblies shall have current "Certificate of Approval from the Foundation for Cross-Connection Control and Hydraulic Research, FCCCHR List." Listing of the specific make, model, design, and size in the FCCCHR List shall be acceptable as the required documentation. Double check valve assembly shall be tested and certified under ASSE 1015. Each check valve shall have a drain.

M. Expansion Tanks:

1. NSF 61; diaphragm type expansion tanks designed for use in potable water systems; butyl diaphragm, polypropylene liner, welded steel shell; constructed, tested hydrostatically and certified in accordance with ASME BPVC SEC VIII D1. Tank shall be equipped with all necessary fittings including stainless steel system connection and welded air charge fitting with plastic cap. Tank and fittings shall have 125 psig (862 kpag) minimum working pressure and 180 degrees F (82 degrees C) minimum operating temperature.
2. Tanks shall be factory pre-charged and field-adjusted to match incoming water pressure.

N. Electric Trap Primer:

1. Trap primer valve and control all housed in moisture proof enclosure complete with UL listed electrical assembly consisting of circuit breaker, switch, and timer solenoid valve designed to operate on 120 VAC, single phase power. Unit shall be rated for minimum range of 32 to 120 degrees F (0 to 49 degrees C) and 20 to 125 psig (138 to 862 kpag), minimum 2 ounces (59 ml) water at 20 psig (138 kpag) per trap served. Inlet and outlet piping connections shall be 1/2-inch (15 mm) NPT.
 - a. Provide distribution unit to serve up to four (4) traps where required.

O. Hose:

1. Kink resistant reinforced rubber hose, corrosion resistant metal couplings, minimum 5 year warranty; size and length as indicated.

2.4 PIPE HANGERS AND SUPPORTS:

- A. See Section 22 05 29.

2.5 SUPPLEMENTARY STEEL AND CHANNELS:

- A. Unless otherwise indicated on the Structural Drawings, provide all supplementary steel and factory fabricated channels required for proper installation, mounting and support of all equipment and systems provided under this Section.
- B. Channels and supplementary steel shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for the specific loading on the system installed herein.
- C. All supplementary steel shall be ASTM A36 factory-formed standard mill finished structural shapes. Channels shall be steel. Supplementary steel assemblies shall be hot dipped galvanized after fabrication and channels shall be hot dipped galvanized where located in the following rooms: 123-127.

2.6 PIPE SLEEVES AND PREFABRICATED FLASHING:

- A. Sleeves in Masonry and Concrete Walls, Floors, Ceilings, and Flat Roofs: Schedule 40 hot dipped galvanized, standard weight ductile-iron or cast-iron pipe sleeves. Sleeves available from the manufacturer of mechanically adjustable segmented elastomeric seals shall be permitted subject to acceptance by the Engineer. Provide minimum 2 inch high waterstop for sleeves in exterior walls and floors.
- B. Sleeves in Non-Masonry or Non-Concrete Walls, Floors, and Roofs: Hot-dip galvanized steel sheet, 26 gage minimum thickness.
- C. Mechanically Adjustable Segmented Elastomeric Seals: Seals shall have EPDM seal elements and steel hardware with corrosion inhibiting coating.
- D. Prefabricated flashing shall be manufactured from EPDM rubber or Silicone with square or round flexible aluminum base. Design shall form watertight, weatherproof seal around pipe and allow flashing to adjust to any roof pitch. Flashing shall be marked to allow accurate trimming for required pipe size.

2.7 PIPE ESCUTCHEONS:

- A. General: Provide pipe escutcheons at all pipe penetrations where penetration is exposed to view as specified herein with inside diameter closely fitting pipe outside diameter. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, wall, or ceilings; and pipe sleeve extension, if any. Escutcheons shall be held in place by internal spring tension or set screws.
- B. Provide pipe escutcheons in finished spaces. Pipe escutcheons shall be of stainless steel, anodized aluminum or chrome-plated brass, solid or split hinged.

2.8 DRIP PANS:

- A. Piping is not permitted in Electrical Rooms and stairwells.
- B. Provide drip pans fabricated from 14 gauge steel sheet and with edges turned up 2-1/2-inches. Reinforce top edge, either by structural angles or by rolling top over 1/4-inch rod made of same material as drip pan sheet metal. Provide hole and 1 inch threaded half coupling for low point drain. Provide hanging brackets of sufficient quantity made of same material as drip pan sheet metal for connecting threaded rods used for suspended drip pans. All joints shall be welded watertight and entire and welded assembly sandblasted, degreased and hot dipped galvanized after fabrication.
- C. Locate drip pans under piping passing over or within 3 feet horizontally of material and equipment defined above, and elsewhere as indicated. Hang from structure with rods and building attachments, fasten rods to brackets on sides of drip pan. Carefully pitch to the drip pan low point for drainage. Brace to prevent sagging or swaying. Drip pans shall be installed within 12 inches below piping.

- D. Provide 1 inch schedule 40 hot dipped galvanized steel drain line from each drip pan and terminate 6 inches above the floor at nearest floor drain.

2.9 ACCESS PANELS:

- A. Access panels shall give access to each valve and cleanout in concealed spaces above non removable (hard) suspended ceilings, and to all other concealed parts of the system. Access panels shall be located where indicated on the Drawings, or where otherwise require accessibility for the proper inspection, operation and maintenance of the system.
- B. Access panels shall be Milcor Type M, 16 inch by 16 inch (400 mm by 400 mm) minimum, as manufactured by Inryco, Inc., or equal. Door shall be constructed of 18 gage (1.311 mm) galvanized steel with frame constructed of 16 gage (1.613 mm) galvanized steel. Casing bead shall be galvanized steel. Hinges shall be steel concealed spring type with steel pin. Locks shall be flush, screwdriver allen head operated, with metal cam. Prime coat shall be factory applied rust-inhibitive light grey paint.

2.10 PLUMBING FIXTURES:

- A. Provide control-stop valves in each supply to each fixture. The finish of fittings, accessories, and supplies exposed to view shall be chromium-plated per ASME A112.18.1M. Centerset faucets shall be top-mounted with inlets on not greater than 8 inch centers. Provide special roughing-in for wheelchair fixtures.
- B. (Accessible) Flush Valve Type Water Closets:
 - 1. ADA compliant, ASME A112.19.2M, flush valve type, white vitreous china, top spud inlet, wall-hung, wall outlet, siphon jet action, elongated bowl, white solid plastic elongated open-front seat, and ASME A112.19.5 trim. Height to top of seat shall be 17 inches (432 mm) to 19 inches (483 mm) above floor.
 - 2. Provide ADA compliant, diaphragm type, exposed solar powered sensor activated flush valve complete with battery back-up and override button to enable flushing during a power outage or at user's discretion. Flush valve shall be of polished chrome plated cast brass, including vacuum breaker and angle (control-stop) valve with back check. Unit shall be equipped with splashproof circuit control module, sensor range adjustment, trouble shooting indicator lights, and variable time-out settings. Mount approximately 30 inches (762 mm) above floor and arrange to avoid interference with grab bars. In addition, the flush valve shall be installed on the wide side of the enclosure.
 - 3. The water flushing volume of the flush valve and water closet combination shall not exceed 1.28 gallons (4.8 liters) per flush.
 - 4. Provide ASME A112.6.1M carrier with feet.
 - 5. Provide ASME A112.6.1M concealed chair carriers with feet.

C. (Accessible) Lavatories:

1. ASME A112.19.2M, white vitreous china, contoured front rim, front concealed overflow, single hole punch, ASME A112.6.1M concealed arm carrier support and chair carrier, minimum dimensions of 20 inches wide by 27 inches (508 mm wide by 686 mm) front to rear, 29 inch (737 mm) minimum clearance from bottom of front rim to floor, 34 inch (864 mm) front rim height above floor.
2. Provide ASME A112.18.1M, ADA-compliant, copper alloy, 24 VAC sensor-operated electronic hand washing faucet with vandal resistant pressure compensating flow control spray head 5 inches (127 mm) above rim. Flow shall not exceed 0.5 gpm (1.9 lpm) at 60 psi (414 kPa) flow pressure. Unit shall be equipped with splashproof circuit control module, sensor range adjustment, trouble shooting indicator lights, variable time-out settings, solenoid valve with wye strainer, metal jacketed protection for control wiring, modular quick release sensor and solenoid connections, and proper size trim plate at base of faucet. Provide plug-in 120/24 VAC transformer for operating up to 2 faucets. Faucet shall be designed for tempered or hot/cold water operation set-up as specified below.
 - a. Provide hot/cold water operation set-up. Set-up shall include back-check tee.
 - b. Provide tempered water operation set-up. Set-up shall include below deck thermostatic mixing valve.
2. Provide perforated grid strainer with offset tailpiece, and 1-1/4 inch (32 mm) adjustable P-trap.

D. Mop Sink Basins:

1. Precast terrazzo receptor, 24 inch (607 mm) by 24 inch (607 mm) by 12 inch high. Flanges shall be provided on all sides mating against wall, and protective caps shall be provided on all exposed sides. Flanges shall be galvanized, bonderized steel cast integral with receptor and extend at least one inch above shoulder for installation against stud wall. Protective caps shall be stainless steel cast integral with receptor. Drain body shall be copper alloy, 3 inch (80 mm) size, floor or wall outlet, cast integral with receptor and shall provide for a non-caulked connection. Terrazzo shall be made of marble chips cast in white portland cement to produce 3,000 psi (20.7 mpa) minimum compressive strength 7 days after casting. Terrazzo surface shall be ground and polished with all air holes and/or pits to be grouted and sealed to resist stains and moisture. Receptor will be reinforced with minimum 16 gage (1.0 square mm) wire.
 - a. Provide ASME A112.18.1M rough chrome-plated copper alloy back-mounted combination (double stop) faucet with vacuum breaker, bucket hook and 3/4-inch (20 mm) external hose threads.

E. Countertop Sinks:

1. ASME A112.19.3M 18 gage (1.27 mm) stainless steel with integral mounting rim, minimum dimensions of 16 inches wide by 20 inches front to rear, single compartment with ledge back and undersides coated with sound dampening material. Provide top-mounted ASME A112.18.1 copper alloy faucets, swing spout with aerator, and stainless steel drain outlets with cup strainers. Flow shall not exceed 2.2 gpm (8.3 lpm) at 60 psi (414 kPa) flow pressure. Provide 1.5 inch (38 mm) adjustable P-trap. Provide UL 430 waste disposer unit in right compartment.

F. (Accessible) Electric Water Cooler:

1. ARI 1010, wall-mounted, non-recessed, bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph (18 lph) minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27 inch (686 kPa) minimum knee clearance from front bottom of unit to floor and 36 inch (914 mm) maximum spout height above floor. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet.

G. Combination Emergency Shower and Eyewash:

1. ADA compliant. ANSI Z358.1; factory assembled and water tested; column mounted shower and eye/face wash fixtures on floor flange. Fixtures shall be operated individually from a common fixture supply line. Provide a self-cleaning, non-clogging 10 inch (254 mm) diameter deluge shower head fixture with elbow and full flow stay-open ball valve having stainless steel pull rod and 8 inch (203 mm) diameter stainless steel ring or triangular handle. Shower head shall be fed by 1 inch (25 mm) branch line, be 7 feet (2,134 mm) above floor and extend 2 feet (610 mm) horizontally from the unit support column/standpipe. Shower shall deliver a minimum of 20 gpm (75.7 lpm) of water at an inlet supply of 30 psig (207 kpag). Provide a self-cleaning, non-clogging eye and face wash fixture with full-flow stay-open ball valve activated by flag handle, eye/face wash bowl, and four spray-type outlet nozzles. Each nozzle shall have "flip top" dust cover, internal flow control and filter. Eye/face wash shall deliver 3 gpm (11.4 lpm) of aerated water at 30 psig (207 kpag) flow pressure, with eye and face wash nozzles 33 to 45 inch (838 to 1,143 mm) above finished floor. Provide copper alloy control valve with stay-open feature such that fixture flow continues uninterrupted until handle is manually returned to closed position. Provide an air-gap with the lowest potable eye and face wash water outlet located above the overflow rim by not less than the Plumbing Code minimum. Pipe and fittings shall be Schedule 40 galvanized steel with support column/standpipe marked for high visibility. Water supply connection shall be 1-1/4 inch (32 mm) female NPT top or side inlet, and 1-1/4 inch (32 mm) female NPT waste outlet. Furnish unit with ANSI-compliant identification sign.
2. Provide the following accessories:

- a. shower head
- b. Powder coated finish on galvanized pipe and fittings
- c. 20 gpm min (75.7 lpm) flow control valve
- d. Privacy curtain for indoor use
- e. Stainless steel bowl cover for eye/face wash fixture cover shall automatically raise when unit is activated
- f. Stainless steel dust covers for each spray nozzle
- g. Thermostatic mixing valve

H. Hose Bibbs:

- 1. Provide angle type copper alloy hose bibb with lockshield and handwheel or tee-handle. Inlet shall have internal threads. Outlet shall have vacuum breaker with 0.75 inch (20 mm) external hose threads.

I. Nonfreeze Wall Hydrant:

- 1. ASSE 1019, cast bronze, with lockshield and removable handwheel or tee-handle, one inch external thread inlet, 0.75 inch (20 mm) external hose thread outlet with automatic draining vacuum breaker. Hydrant shall be of sufficient length to extend through walls and place the valve seat inside the building. Bonnet and valve stem shall be removable from outside of the building.

J. Trench Drains:

- 1. Modular type system designed for placement in cast concrete floors, width and length as indicated. Channel sections shall be made of HDPE plastic with interlocking ends and curved bottom. Channels shall be provided with 1 percent built-in slope. Minimum invert shall be 6 inches. Channel system shall have provisions for positioning and anchoring in concrete slab. System shall include acid resistant coated or stainless steel frame to distribute weight between grate and channel. Outlets shall be no-hub end, bottom, or side outlet type as indicated, 4, 6, or 8 inch size as indicated.
- 2. Grates shall be heavy duty, with material as indicated on drawings to match environment (ductile iron, acid resistant coated ductile iron, galvanized steel, galvanized ductile iron, stainless steel, fiberglass reinforced polyester (FRP), etc. with slotted or bar type pattern. Grates shall be Class C rated, unless otherwise indicated. Where metal covers are utilized, AIS Compliance of these materials is required. Refer to Section 22 05 00, 1.01 E for description.

2.11 GAS-FIRED DOMESTIC WATER HEATERS (SEALED COMBUSTION/DIRECT VENT):

- A. Domestic water heaters shall be UL listed, NSF certified, natural gas-fired of sealed combustion/direct vent design, UL listed, minimum 95 percent thermal efficiency condensing type, and certified for 150 psig (1,034 kpag) maximum working pressure. Water heaters shall have low NO_x emissions meeting SCAQMD Rule 1146.2 and designed for zero clearance to all combustible surfaces.
- B. Domestic water heaters shall be constructed of series 300 stainless steel requiring no anode rods. The primary condensing heat exchanger shall be constructed of 90/10 cupronickel. Tank insulation shall be non-CFC, polyurethane rigid foam minimum 2 inch thick (50 mm) enclosed in a high impact plastic shell. All components shall be located in the front of the water heater and accessible through a removable cover. All related hardware shall be constructed of stainless steel studs and brass nuts.
- C. The control panel shall be an integrated solid state temperature and ignition control device with integral diagnostics, LED fault display capability and a digital display of water temperature, set point and differential. Temperature set point range shall be from 70 to 160 degrees F (21 to 71 degrees C).
- D. Each water heater shall be supplied with an AGA/ASME rated combination pressure/temperature safety relief valve sized per the domestic water heater manufacturer's recommendations.
- E. Combustion system shall be complete with control board, control well and E.C.O., transformer, gas burner, gas valve, hot surface ignitor, flame probe, combustion blower, vent over-temperature sensor, reset switch, and pressure switch.
- F. All related intake air and exhaust gas piping shall be acceptable for zero clearance to any combustible surface. Intake air, exhaust gas, and condensate drain piping shall be installed in strict accordance with domestic water heater manufacturer instructions and local code.

2.12 GAS VENTS:

- A. NFPA 211, Type B, of the prefabricated multi-wall UL listed type. Vents shall be rigid, round vent pipe with aluminum alloy inner liner and galvanized steel outer casing. Provide fittings, thimbles, bird proof top (top of stack discharge), roof flashing, adapters, connectors and supports.

2.13 RECIRCULATION PUMPS:

- A. Select the pump so that the operating point on the characteristic performance curve for the impeller size to be furnished will be to the left (shut-off side) of and not more than 5 percent below the point of maximum efficiency for the impeller to be furnished. Provide lifting attachments on pumps larger than 2 horsepower (1.5 kW).

B. In Line Centrifugal Pumps:

1. In-line pumps shall be close coupled direct driven and have all-bronze construction, including bronze casings, alloy steel shafts with copper alloy shaft sleeves, and bronze impellers. Impeller shall be statically and dynamically balanced. Bearings shall be either sleeve type or sealed ball bearings. Shaft seals shall be mechanical seals. Provide casing wear rings, drain and vent connections with threaded plugs, suction and discharge pressure gage tapings with threaded plugs, and flexible coupling or direct drive connection between pump and motor. If the scheduled pump includes ball bearings and a direct drive motor to impeller connection, the submitted pump shall not have sleeve bearings or a flexible coupling between pump and motor.

C. Wet Rotor Pumps:

1. Pumps shall be single stage. Pumps shall have cast iron casing, ceramic shaft, carbon bearings, EPDM o-rings and gaskets, and non-metallic impellers. Pumps shall have replaceable bronze cartridge containing all moving parts of the pump. Pumps shall be self-lubricating with no mechanical seal. Pumps shall have thermally protected permanent split capacitor motor and stator housing. Provide anti-condensate baffle with ambient air flow to protect motor windings against condensate buildup.

D. Flexible Connectors:

1. Provide flexible connectors at pumps. All connectors shall be installed on the equipment side of shutoff valves, horizontal and parallel to shafts whenever possible. Connectors shall be manufactured of nylon tire cord and EPDM, both molded and cured in hydraulic presses and rated at 250 psig/170 degrees F (1,724 kpag/77 degrees C), dropping in a straight line to 170 psig/250 degrees F (1,172 kpag) for sizes 1-1/2 to 12 inch (40 to 300 mm). Neoprene in lieu of EPDM shall not be acceptable. Straight connectors to have two (2) spheres reinforced with a molded-in, external ductile iron ring between the spheres.
2. Connectors shall be pre-extended per manufacturer's recommendation to prevent elongation under pressure. Connectors bolted to gate, butterfly or check valves to have a minimum 5/8-inch (16 mm) flange spacer installed between the connector and the coupling flange. Minimum safety factor of 3.6:1 at a maximum pressure rating shall be certified by test reports. Submittals shall also include two test reports by independent consultants showing minimum reduction of 20 Db in vibration accelerations and 10 Db in sound pressure levels at typical blade passage frequencies.
3. Connectors shall be Mason Ind. Super-Flex type MFTNC or NTFU, or acceptable equivalent product.

2.14 FLUE GAS CONDENSATE PUMPS:

- A. UL listed, rated for high efficiency gas burning appliances producing acidic condensate and intermittent liquid temperatures up to 120 degrees F (49 degrees C). Units shall be equipped with vertical type pump, stainless steel motor shaft, high impact and corrosion resistant tank and motor cover, 3/8-inch (10 mm) OD barbed tubing adapter and check valve, and motor thermal overload protection.

2.15 SUMP PUMPS (SUBMERSIBLE TYPE):

- A. UL listed, factory assembled and tested submersible type pumps for operation under water up to maximum 120 degrees F (49 degrees C) or higher and capable of passing minimum 1/2-inch (13 mm) spherical solids. Pump shall be complete with cast-iron casing with corrosion resistant finish, cast iron or bronze impeller, stainless steel shaft, carbon/ceramic mechanical seals, sealed heavy-duty ball bearings, water-cooled hermetically-sealed motor, built-in automatic reset thermal protection, stainless steel lift handle, and waterproof three-conductor cables and grounded plugs. Pumps shall have single seal design.
- B. Provide adjustable/variable level float switch complete with waterproof three-conductor cable and grounded plug. Plug shall be designed for piggybacking into pump grounded plug. Float shall have plastic encased variable level switch designed for use in minimum 18 inch (457 mm) diameter sump. Variable level control switch shall be normally open when hanging down vertically above sump liquid level, and close when it reaches a few degrees above the horizontal position.
- C. Provide UL listed alarm panel complete with high water alarm light, high water alarm horn with alarm test and horn silence switch, 115 VAC auxiliary dry high level alarm contacts, and NEMA 4X thermoplastic enclosure. Alarm panel shall operate on 115 VAC circuit separate from pump.
- D. Select the pump so that the operating point is in the middle one half of the characteristic performance curve for the pump to be furnished.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Installation, workmanship, inspection, and testing shall be in accordance with the specified Plumbing Code, Energy Conservation Code, and Building Code with the additions specified herein. Install piping straight and true to bear evenly on hangers and supports. Keep the interior and ends of new piping and existing piping affected by the Work thoroughly cleaned of water and foreign matter. Keep piping systems clean during installation by means of plugs or other acceptable methods. When work is not in progress, securely close open ends of piping to prevent entry of water and foreign matter. Inspect piping before placing into position. When fixtures require both hot

water and cold water supplies, provide the hot water supply to the left of the cold water supply.

- B. Copper tube extracted joints shall not be permitted.
- C. Piping shall not be permitted in Electrical Rooms and stairwells.
- D. Piping and other apparatus shall not be installed in such a manner so as to interfere with the full swing of doors, movement of personnel and equipment, and access to other equipment.
- E. Install aboveground pressurized piping to permit draining of all sections of each piping systems without traps. Pitch piping back to system low points. Provide drain valves at all piping low points.
- F. Make provisions for pipe expansion and contraction with suitable anchors and offsets, expansion joints, or expansion loops. Install piping to allow freedom of movement in all planes without imposing undue stress on any section of the main piping, branch piping, equipment and structure.
- G. Buried Piping:
 - 1. Pipe bedding and compacted backfill to a point 12 inches (300 mm) above crown of buried pipe shall be provided under this Section of the Specifications in accordance with the requirements of Section 31 23 33.
 - 2. Pipe bedding shall be 6 inches (150 mm) deep. Bedding and compacted backfill shall be non-corrosive material such as cleaned washed sand, and contain no stones, metal, rubbish of any kind, frozen material, organic matter, or any other material capable of damaging piping or coating, and/or of settling.
 - 3. Where feasible, install buried lines in a single trench. Trenches shall be wide enough to permit at least 6 inches (150 mm) spacing between lines and the sides and floor of the trench.
 - 4. Terminate buried piping not more than 6 inches (150 mm) above finished ground surface or floor slab-on-grade, or from foundation wall inside surface.
 - 5. Make provisions in buried piping for differential settlement.
 - 6. Completely encase buried copper tubing, ductile-iron piping, and cast iron piping with polyethylene tube or sheet in accordance with AWWA C105.
- H. Threaded Connections:
 - 1. Jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread paste, pipe cement and oil, or PTFE powder and oil; apply only on male threads. Provide exposed ferrous pipe threads with one coat of primer applied to a

minimum dry film thickness of 1.0 mil (0.03 mm). Do not thread metal pipe into plastic piping.

I. Soldered Connections:

1. Soldering shall be performed in accordance with best soldering practice. Before soldering copper tubing joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Provide suitable flux for use with solder. Surplus soldering material shall be removed at all joints. Piping shall be supported prior to soldering and not be sprung or forced.
2. For solder end valves, remove stems and washers and other items subject to damage by heat during installation. Reassemble valve after soldering is complete. Valves without heat sensitive parts do not require disassembly but shall be fully opened during soldering.

J. Brazed Connections:

1. Brazing of copper tubing joints shall be performed in accordance with AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be continuously purged with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Piping shall be supported prior to brazing and not be sprung or forced.

K. Flanged Connections:

1. Flanges shall be faced true and made square and tight.

L. Pipe Hangers and Supports:

1. See Section 22 05 48

M. Seismic Bracing Requirements:

1. Piping and equipment shall be supported and braced to resist seismic loads where required by the specified Building Code. Provide seismic restraints in accordance with the SMACNA Seismic Restraint Unit.
2. See Section 22 05 48

N. Pipe Through-Penetrations:

1. Furnish pipe sleeves where piping passes through walls, floors, ceilings, roofs, and partitions. Sleeves will be installed, and secured in proper position and location

during construction by the trade whose element will be penetrated. Such trades include concrete, masonry, steel siding in the case of a steel building, and dry wall and/or plaster in the case of framed construction. Furnish sleeves of sufficient length to pass through entire thickness of walls, floors, ceilings, roofs, and partitions.

2. Pipe Penetrations Through Building Interior Construction: Provide not less than 1/4-inch (8 mm) space between exterior of piping or pipe insulation and interior of sleeve. Firmly pack space with mineral wool insulation. For non-fire rated assemblies, seal at both ends of the sleeve with plastic waterproof cement which will dry to a firm but pliable mass or silicone. Seal both ends of penetrations through fire rated assemblies to maintain fire resistive integrity with UL listed fill, void, or cavity material.
3. Pipe Penetrations Through Building Exterior Construction: Provide a mechanically adjustable segmented elastomeric seal, with sleeve sized as recommended by seal manufacturer.
4. Extend sleeves in floor slabs 2 inches (51 mm) above the finished floor, except sleeves are not required where drain, waste and vent piping passes through concrete floor slabs located on grade. Sleeves through walls shall terminate flush with the finished surface on either side of the wall.

O. Cross Connection and Interconnections:

1. No equipment, devices or piping shall be installed which will provide a cross or interconnection between a domestic water supply and a drainage, soil or waste pipe which will permit or make possible the backflow of sewage, polluted water or waste into the domestic water supply system.

P. Connections to Existing Water Supply Systems:

1. Use tapping or drilling machine valve and mechanical joint type sleeves for connections to be made under pressure. Bolt sleeves around the main piping; bolt valve conforming to AWWA C500 to the branch connection. Open valve, attach drilling machine, make tap, close valve, and remove drilling machine, without interruption of service. Notify the Engineer and CM in writing at least 15 days prior to connection date and receive acceptance before any service is interrupted. Furnish materials required to make connections into the existing water supply systems and perform excavating, backfilling, surface restoration and other incidental labor.

3.02 FIELD QUALITY CONTROL:

- A. General: After system installation has been completed and prior to initial operation, inspect piping and control wiring systems for compliance with Drawings, Specifications, and accepted submittals. Perform flushing and tests in compliance with the specified

Plumbing Code with the additions specified herein. Have piping accepted by the Engineer and CM before insulating or otherwise concealing.

B. Test Procedures and Reports:

1. Prepare and submit procedures for all specified tests to the Engineer and CM for acceptance prior to the planned preliminary tests. Test reports shall include accepted test procedures, test results, deficiencies identified, and recommended corrective actions. Provide a complete explanation including supporting documentation detailing the design deficiencies. State that no deficiencies are evident if that is the case.
2. Material and equipment used in testing shall be subject to inspection by the Engineer and/or CM. Provide water, electricity, instruments, appliances, equipment, connecting devices, and personnel for the tests.
3. When tests have been completed and corrections made, submit signed and dated test reports.
4. Test each new system to demonstrate compliance with the contract requirements. Tests shall be witnessed by the Engineer and/or CM. Correct defects in the Work and repeat tests until Work is in compliance with contract requirements.
5. Gages used in pressure tests shall have been calibrated within the 6-month period preceding the tests. Leaks found during tests shall be repaired by replacing pipe and/or fittings and the system retested. Caulking of joints shall not be permitted.

C. Tests:

1. Domestic Water Piping and Service Water Piping Pressure Tests: Before applying insulation, and before the installation of fixtures, cap ends of each system and hydrostatically test each piping system at not less than 125 psig (862 kpag) systems working pressure for a period of time sufficient for inspection of every joint in the system but in no case less than 2 hours. During the pressure test, there shall be no leakage or reduction in pressure.
2. Drain, Waste and Vent Piping Pressure Tests: Before the installation of fixtures, provide Drainage and Vent Water Test or Air Test in compliance with the specified Plumbing Code. Each test shall be for a period of time sufficient for inspection of every joint in the system but in no case less than 30 minutes. During the pressure test, there shall be no drop in water level or air pressure.
 - a. After plumbing fixtures have been set and their traps filled with water, subject the entire sanitary system to a Drainage and Vent Final Test in compliance with the specified Plumbing Code. The entire system shall be proven absolutely tight under such test.

3. Backflow Preventer Tests: Backflow preventers shall be tested by a locally approved and certified backflow assembly tester. A copy of the test report shall be provided to the Engineer, CM and Owner prior to placing the domestic water system into operation, or no later than 5 days after the test.
4. Functional Testing All control devices and signaling devices shall be tested individually to demonstrate proper operation. Test all control panel functions to demonstrate proper operation. Test all control system functions to demonstrate proper operation in accordance with the specified control sequences. Monitoring signals to the facility Supervisory Control and Data Acquisition (SCADA) system shall be verified.

D. Flushing:

1. After completion of testing and before placing in operation, flush all new piping including water feed mains of all foreign matter. Use the permanent water service at its maximum available pressure as the source of flushing water. Remove integral strainer screens, aerators, shower heads, hose end vacuum breakers, and other devices susceptible to clogging prior to flushing and re-install upon completion. Flush piping through each fixture outlet, strainer blowdown and equipment drain valve. Discharge used water to sanitary sewer. Remove and provide new screens in strainers after flushing is completed. System shall be drained prior to final filling.
2. The system shall be thoroughly flushed, in no case for less than 2 hours at the design flow rate, of all foreign matter until a white linen bag installed in a strainer basket shows no evidence of contamination. The white linen bag shall be in the strainer basket during the entire flushing operation prior to its being presented to the Engineer and/or CM for acceptance. The Engineer and/or CM will inspect the linen bag prior to completion of flushing and approve the flushing operation.

3.03 MANUFACTURERS INSTRUCTIONS AND SERVICES:

- A. Obtain instructions from the manufacturer for the proper method of installation and connection of the equipment that is to be installed. Obtain all information that is necessary to facilitate the Work and to complete the project.
- B. Provide manufacturer's service in accordance with Section 01 78 23. Services shall be provided for the satisfactory completion of installation, start-up, testing and training for those equipment and systems described herein below.
 1. Domestic water heaters.
 2. Sump pumps.
- C. Field Training: For equipment and systems described herein above, provide separate field training course for designated operating and maintenance staff members. Training shall be provided for a minimum period of 5 hours of normal working time and shall

start after the subject equipment and systems are functionally complete but prior to final acceptance tests. The training shall include discussion of the system design and layout and demonstrations of routine operation and maintenance procedures. This training shall include: normal system operation and control; flow balancing; detection of a nonfunctioning system due to sensor, controller, and/or mechanical failure; filling, draining, and venting of the system; replacement of sensors, equipment, and equipment components; cleaning and inspection for leaks; and expansion tank charging if applicable.

- D. Upon completion of all Work, furnish, in duplicate, certificates of inspection from equipment manufacturers stating that authorized factory engineers have inspected and tested the operation of their respective equipment and systems and found same to be in satisfactory operating condition, and have trained operating and maintenance staff.

3.04 DISINFECTION:

- A. Disinfect the new water piping in accordance with the specified Plumbing Code with the additions specified herein or AWWA C651 whichever is more stringent. Fill piping systems with chlorine solution and allow solution to stand. Following the required standing time, flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 ppm, or the residual chlorine content of domestic water supply. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyzed by a certified laboratory, and submit results prior to the new water piping being placed into service.
- B. Where it is not possible to disinfect a potable water storage tank as specified above, the entire interior of the tank shall be swabbed with a solution which contains 200 parts per million of available chlorine; and the solution shall then be allowed to stand 3 hours before the tank is flushed and returned to service.
- C. For a potable water filter or similar device, the dosage shall be determined by the Utah Department of Environmental Protection.

3.05 PAINTING:

- A. Field painting of above ground plumbing piping shall be provided under this Section in accordance with Section 09 91 13.
- B. Field touch up all damaged factory or shop applied coatings for material and equipment furnished under this Section in accordance with the manufacturer's recommendation.
- C. Provide painting system, under this Section, of the following.
 - 1. Hangers and supports in exposed locations.
 - 2. Pipe, fittings and valves in exposed locations.
 - 3. Piping insulation jackets in exposed locations.

- D. Do not apply field painting and touch-up until after installation and testing is completed and system accepted.

3.06 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 05 19

METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide meters and gages for plumbing piping as indicated and in compliance with Contract Documents.
 - 1. Thermometers
 - 2. Pressure Gages
 - 3. Test Plugs

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.1: Unified Inch Screw Threads (UN and UNR Thread Form)
 - 2. B1.20.1: Pipe Threads, General Purpose (Inch)
 - 3. B40.100: Pressure Gauges and Gauge Attachments
 - 4. B40.200: Thermometers, Direct Reading and Remote Reading

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product. Submit manufacturer's technical product data, including installation instructions for each type of meter and gage. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
- C. Product Certificates: For each type of meter and gage.
- D. Operation and Maintenance Data: For each type of meters and gages to include in operation and maintenance manuals.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of meters and gages, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- C. Codes and Standards:
 - 1. UL Compliance: Comply with applicable UL standards pertaining to meters and gages.
 - 2. ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages.
- D. Certification: Provide meters and gages whose accuracies, under specified operating conditions, are certified by manufacturer.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS:

- A. Manufacturers:
 - 1. Palmer - Wahl Instruments Inc.
 - 2. Miljoco Co.
 - 3. Terice, H. O. Co.
 - 4. Weiss Instruments, Inc.
 - 5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division.
- B. Case: Die-cast aluminum or brass, 7 inches to 9 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass.

- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. Accuracy: Plus or minus 1 scale division.

2.02 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS:

- A. Manufacturers:
 - 1. Miljoco Co
 - 2. Trerice, H. O. Co.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division
- B. Type: Vapor Tension, Universal Angle Brass.
- C. Case: Liquid-filled type, metal, 4-1/2-inch diameter.
- D. Element: Bourdon tube.
- E. Movement: Brass precision geared.
- F. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- G. Pointer: Red or other dark-color metal.
- H. Window: Glass.
- I. Ring: Brass or Stainless steel.
- J. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- K. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.
- L. Accuracy: Plus or minus 1 scale division.

2.03 BIMETALLIC-ACTUATED DIAL THERMOMETERS:

- A. Manufacturers:
 - 1. Ernst Gage Co.

2. Eugene Ernst Products Co.
3. Miljoco Co.
4. Terice, H. O. Co.
5. Weiss Instruments, Inc.
6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division

B. Type: Bi-metal stainless steel case and stem.

C. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

D. Case: Liquid-filled type, stainless steel with 3-inch to 5-inch diameter

E. Element: Bimetal coil

F. Dial: 1 inch diameter, dust and leak proof

G. Pointer: Red or other dark-color metal

H. Window: Glass

I. Ring: Stainless steel

J. Connector: Adjustable angle type

K. Stem: 1/8 inch diameter with nominal length of 5 inches

L. Accuracy: 0.5 percent of dial range

2.04 DIGITAL THERMOMETERS:

A. Manufacturers:

1. Weksler Glass Thermometer Corporation
2. Weiss Instruments, Inc.

B. Case: High Impact ABS, black plastic

C. Range: -40 degrees to 300 degrees F

D. Display: LCD, 3/8 inches

E. Accuracy: 1 percent of reading

F. Lux Rating: 10 Lux (1 foot candle)

2.05 THERMOWELLS:

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Provide thermowells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2: extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

2.06 PRESSURE GAGES:

- A. Manufacturers:
 - 1. AMETEK, Inc.; U.S. Gauge Division
 - 2. Miljoco Co
 - 3. Trerice, H. O. Co.
 - 4. Weiss Instruments, Inc.
 - 5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division
- B. General use type complying with ANSI B40, Grade A.
- C. Case: Liquid-filled type, drawn steel or Brass, 4-1/2-inch diameter.
- D. Pressure-Element Assembly: Phosphor bronze Bourdon tube.
- E. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
- F. Movement: Mechanical, with link to pressure element and connection to pointer.
- G. Dial: White coated aluminum with permanently etched scale markings.
- H. Pointer: Red or other dark-color metal.
- I. Window: Glass.
- J. Ring: Brass or Stainless steel.
- K. Accuracy: Grade A, 1 percent scale.
- L. Pressure Range:
 - 1. Vacuum: 30-in. Hg of vacuum to 15 psig of pressure
 - 2. Water: 0-100 psi

M. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.07 TEST PLUGS:

A. Manufacturers:

1. MG Piping Products Co.
2. Miljoco Co.
3. Peterson Equipment Co., Inc.
4. Trerice, H. O. Co.
5. Watts Industries, Inc.; Water Products Division

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 degrees F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for water service at 20 to 200 degrees F shall be CR.
2. Insert material for water service at minus 30 to plus 275 degrees F shall be EPDM.

2.08 SIGHT FLOW INDICATORS:

A. Description: Piping inline-installation device for visual verification of flow.

B. Construction: Bronze or stainless-steel body, with sight glass and paddle wheel indicator, and threaded or flanged ends.

C. Minimum Pressure Rating: 150 psig

D. Minimum Temperature Rating: 200 degrees F

E. End Connections for NPS 2 and Smaller: Threaded

F. End Connections for NPS 2-1/2 and Larger: Flanged

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install remote-mounted pressure gages on panel.
- I. Install valve and snubber in piping for each pressure gage for fluids.
- J. Install test plugs in piping tees.
- K. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlets and outlets of each domestic water heat exchanger.
 - 3. Inlet and outlet of each domestic hot-water storage tank.
- L. Install pressure gages in the following locations:
 - 1. Building water service entrance into building.
 - 2. Inlet and outlet of each pressure-reducing valve.
 - 3. Suction and discharge of each domestic water pump.

3.02 CONNECTIONS:

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.03 ADJUSTING:

- A. Adjust faces of meters and gages to proper angle for best visibility.

3.04 APPLICATIONS:

A. Thermometer Applications:

1. Install thermometers in the outlet of each domestic water heater and each domestic, hot-water storage tank.
2. Install liquid-filled-case-type, bimetallic-actuated dial thermometers at suction and discharge of each pump.
3. Install thermometers at inlets and outlets of each domestic water heat exchanger.
4. Install thermometers at inlet and outlet of each remote domestic water chiller.
5. Thermometer stems shall be of length to match thermowell insertion length.
6. Provide the following temperature ranges for thermometers:
 - a. Domestic Hot Water: 30 to 180 degrees F, with 2-degree scale divisions
 - b. Domestic Cold Water: 0 to 100 degrees F, with 2-degree scale divisions

B. Gage Applications:

1. Install pressure gages at discharge of each water service into building.
2. Install pressure gages for discharge of each pressure-reducing valve.
3. Install pressure gages at suction and discharge of each pump.
4. Install pressure gages at suction and discharge of each domestic water pump shall.
5. Provide the following pressure ranges for thermometers:
 - a. Scale Range for Water Service Piping: 0 to 100 psi
 - b. Scale Range for Domestic Water Piping: 0 to 100 psi

3.05 INSTALLATIONS:

1. Install direct-mounting thermometers and adjust vertical and tilted positions.
2. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
3. Install thermowells with socket extending a minimum of 2 inches into fluid to center of pipe and in vertical position in piping tees where thermometers are indicated.
4. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
5. Install remote-mounting pressure gages on panel.
6. Install needle-valve and snubber fitting in piping for each pressure gage.
7. Install test plugs in tees in piping.
8. Install permanent indicators on walls or brackets in accessible and readable positions.
9. Install connection fittings for attachment to portable indicators in accessible locations.
10. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.
11. Adjust faces of thermometers and gages to proper angle for best visibility.

3.06 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide hangers and supports for plumbing piping and equipment as indicated and in compliance with Contract Documents.
 - 1. Metal pipe hangers and supports
 - 2. Trapeze pipe hangers
 - 3. Fiberglass pipe hangers
 - 4. Metal framing systems
 - 5. Fiberglass strut systems
 - 6. Thermal hanger-shield inserts
 - 7. Fastener systems
 - 8. Pipe stands
 - 9. Pipe-positioning systems
 - 10. Equipment supports

1.02 REFERENCES:

- A. American Society of Civil Engineers (ASCE):
 - 1. 7: Minimum Design Loads for Buildings and Other Structures
- B. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code
 - 2. B31.9: Building Services Piping
- C. ASTM International (ASTM):
 - 1. A36: Standard Specification for Carbon Structural Steel
 - 2. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

3. A780: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
4. A1011: Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
5. B221: Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
6. C552: Standard Specification for Cellular Glass Thermal Insulation.
7. C591: Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
8. C1107: Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
9. D635: Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
10. E84: Standard Test Method for Surface Burning Characteristics of Building Materials

D. American Welding Society (AWS):

1. D1.1: Structural Welding Code – Steel

E. International Association of Plumbing and Mechanical Officials (IAPMO):

1. PS 42: Pipe Alignment and Secondary Support Systems

F. Manufacturer Metal Framing Systems (MFMA):

1. 4: Standard for Integrated Fire Protection and Life Safety System Testing
2. 103: Standard for Metal Framing Selections and Applications

G. Manufacturers' Standardization Society (MSS):

1. SP-58: Pipe Hangers and Supports - Materials and Design.

H. Underwriters' Laboratories, Inc. (UL):

1. 94: Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Fiberglass strut systems.
 - 4. Pipe stands.
 - 5. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Include design calculations for designing trapeze hangers.
- D. Welding certificates.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1.
- C. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

2.01 PERFORMANCE REQUIREMENTS:

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 43 00, to design trapeze pipe hangers and equipment supports.
- B. AIS Compliance of these materials is required. Refer to Section 22 05 00, 1.01 E for description.
- C. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

A. Carbon-Steel Pipe Hangers and Supports:

1. Compliance: AIS Compliance required. Manufacturer listed is the Basis of Design for performance product requirements. Contractor to submit compliant manufacturer if Basis of Design cannot certify AIS compliance.
2. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
3. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
4. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
5. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Compliance: AIS Compliance required. Manufacturer listed is the Basis of Design for performance product requirements. Contractor to submit compliant manufacturer if Basis of Design cannot certify AIS compliance.

2. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
3. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Compliance: AIS Compliance required. Manufacturer listed is the Basis of Design for performance product requirements. Contractor to submit compliant manufacturer if Basis of Design cannot certify AIS compliance.
2. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.03 TRAPEZE PIPE HANGERS:

- A. Compliance: AIS Compliance required. Manufacturer listed is the Basis of Design for performance product requirements. Contractor to submit compliant manufacturer if Basis of Design cannot certify AIS compliance.
- B. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.04 METAL FRAMING SYSTEMS:

A. MFMA Manufacturer Metal Framing Systems:

1. Compliance: AIS Compliance required. Manufacturer listed is the Basis of Design for performance product requirements. Contractor to submit compliant manufacturer if Basis of Design cannot certify AIS compliance.
2. Manufacturers:
 - a. G-STRUT
 - b. Powerstrut Corp.
 - c. Unistrut Corp.
3. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.

- ## 2.05 THERMAL HANGER-SHIELD INSERTS:

- ## 2.06 FASTENER SYSTEMS:

- ## 2.07 PIPE STANDS:

- Hangers and Supports for Plumbing Piping and Equipment
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4. Accessories: Protection pads
- C. Low-Profile, Single-Base, Single-Pipe Stand:
 1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate
 3. Vertical Members: Two galvanized-steel, continuous-thread, 1/2-inch rods
 4. Horizontal Member: Adjustable horizontal, galvanized-steel pipe support channels
 5. Pipe Supports: Roller
 6. Hardware: Galvanized steel
 7. Accessories: Protection pads
 8. Height: 12 inches above roof
- D. High-Profile, Single-Base, Single-Pipe Stand:
 1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 2. Base: Single vulcanized rubber or molded polypropylene
 3. Vertical Members: Two galvanized-steel, continuous-thread, 1/2-inch rods
 4. Horizontal Member: One adjustable-height, galvanized-steel, pipe-support slotted channel or plate
 5. Pipe Supports: Clevis hanger
 6. Hardware: Stainless steel
 7. Accessories: Protection 1/2-inch, continuous-thread, stainless-steel rod
 8. Height: 36 inches above roof
- E. High-Profile, Multiple-Pipe Stand:
 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 2. Bases: Two or more; molded polypropylene
 3. Vertical Members: Two or more, galvanized-steel channels

4. Horizontal Members: One or more, adjustable-height, galvanized-steel pipe support
 5. Pipe Supports: Strut clamps
 6. Hardware: Galvanized steel
 7. Accessories: Protection pads, 1/2-inch, continuous-thread rod
 8. Height: 36 inches above roof
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.
- 2.08 PIPE-POSITIONING SYSTEMS:
- A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.
- 2.09 EQUIPMENT SUPPORTS:
- A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.
1. Compliance: AIS Compliance required. Manufacturer listed is the Basis of Design for performance product requirements. Contractor to submit compliant manufacturer if Basis of Design cannot certify AIS compliance.
- 2.10 MATERIALS:
- A. Aluminum: ASTM B221
 - B. Carbon Steel: ASTM A1011
 - C. Structural Steel: ASTM A36 carbon-steel plates, shapes, and bars; black and galvanized
 - D. Stainless Steel: ASTM A240
 - E. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications
1. Properties: Non-staining, noncorrosive, and nongaseous
 2. Design Mix: 5000-psi, 28-day compressive strength

PART 3 - EXECUTION

3.01 APPLICATION:

- A. Comply with requirements in Section 07 84 00 for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 pounds.

3.02 HANGER AND SUPPORT INSTALLATION:

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A36 carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

- G. Pipe Stand Installation:
1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 for curbs.
- H. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
- N. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- P. Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

- ## Hangers and Supports for Plumbing Piping and Equipment
- ### Section No. 22 05 29-14

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 degrees F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 degrees F piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 pounds

- b. Medium (MSS Type 32): 1500 pounds
 - c. Heavy (MSS Type 33): 3000 pounds
- 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 - 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 - 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 - 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 - 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 - 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 - 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

- a. Horizontal (MSS Type 54): Mounted horizontally.
- b. Vertical (MSS Type 55): Mounted vertically.
- c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

S. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.08 CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 05 48

VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide vibration and seismic controls for plumbing piping and equipment as indicated and in compliance with Contract Documents.

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.
17. Adhesive anchor bolts.

1.02 REFERENCES:

- A. ASTM International (ASTM):

1. A492: Standard Specification for Stainless Steel Rope Wire
2. A603: Standard Specification for Zinc-Coated Steel Structural Wire Rope
3. E488: Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

B. American Welding Society (AWS):

1. D1.1/D1.1M: Structural Welding Code – Steel

C. Manufacturer Metal Framing Systems (MFMA):

1. 4: Standard for Integrated Fire Protection and Life Safety System Testing

D. Manufacturers' Standardization Society (MSS):

1. SP-127: Bracing for Piping Systems: Seismic – Wind – Dynamic Design, Selection, and Application

E. FM Global (FM):

1. Data Sheet 2-8: Earthquake Protection for Water-Based Fire Protection Systems.

1.03 DEFINITIONS:

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.04 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Written certification from Professional Engineer licensed in the State of Utah stating that supports systems and anchorage for equipment have been designed according to requirements of indicated according to Section 1613 of the building codes of Utah, Salt lake City and ASCE/SEI 7 for post-disaster structures at time of shop drawing submittals.

B. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

C. Shop Drawings:

1. Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components. Detail bases, and show location of equipment anchoring points, coordinated with equipment manufacturer's shop drawings.
 - a. Shop drawings showing structural design and details of inertia bases, steel beam bases and other custom-fabricated work not covered by manufacturer's submitted data.
 - (1) Furnish templates, anchor bolts and sleeve for equipment bases, foundations and other support systems for coordination of vibration isolation units with other work.
2. Submit shop drawings indicating scope of vibration isolation work and locations of units and flexible connections. Include support isolation points for piping and ductwork including risers, air housings and inertia bases.
 - a. Include schedule of units, showing size or manufacturer's part number, and weight supported and resulting deflection of each unit.

D. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints. Provide calculations to Engineer and FM global representative at least two weeks prior to beginning of construction.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
 - e. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
 - f. Qualification Data: For professional engineer and testing agency.

E. Welding certificates.

F. Field quality-control reports.

1.05 SUSTAINABLE DESIGN:

A. Comply with the requirements specified in Section 01 81 13.

1.06 SPARE PARTS:

A. Comply with the requirements specified in Section 01 61 00.

1.07 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

B. Sustainability Standards Certifications.

- C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
 - D. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
 - E. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - F. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- 1.08 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS:

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: IV
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): .92
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: .61
 - 5. Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
- B. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least **four** times the maximum seismic forces to which they are subjected.

2.2 ELASTOMERIC ISOLATION PADS:

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Waffle pattern.
5. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS:

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS:

A. Restrained Elastomeric Isolation Mounts:

1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS:

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS:

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top housing with attachment and leveling bolt

2.7 RESTRAINED-SPRING ISOLATORS:

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top plate with Threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS:

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT:

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES:

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene
 - 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS:

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
 - 1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS:

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
 - 1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 - 8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS:

- A. Manufacturers:
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS:

- A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINT CABLES:

- A. Restraint Cables: ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES:

- A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.17 MECHANICAL ANCHOR BOLTS:

- A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.18 ADHESIVE ANCHOR BOLTS:

- A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS:

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.
- D. Hangers and Supports for Plumbing Piping and Equipment:
 - 1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

- a. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - (1) Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - (2) Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - (3) Design seismic-restraint hangers and supports for piping and equipment.
 - 2. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- E. Sanitary Waste and Vent Piping:
- 1. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - 3. Install seismic restraints on piping.
- F. Storm Drainage Piping:
- 1. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - 2. Install seismic restraints on piping.
- G. Water Heaters:
- 1. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - 2. Install commercial, electric, domestic-water heaters with seismic-restraint devices
- 3.03 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION:
- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00.
 - B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
 - C. Comply with requirements in Section 07 72 00 for installation of roof curbs, equipment supports, and roof penetrations.
 - D. Equipment Restraints:
 - 1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
 - E. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
 - F. Install cables so they do not bend across edges of adjacent equipment or building structure.
 - G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
 - H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

- I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- K. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION:

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 11 16 for piping flexible connections.

3.05 FIELD QUALITY CONTROL:

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
 3. **Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.**
 4. **Test at least four of each type and size of installed anchors and fasteners selected by Architect.**
 5. **Test to 90 percent of rated proof load of device.**
 6. **Measure isolator restraint clearance.**
 7. **Measure isolator deflection.**
 8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.
- 3.06 ADJUSTING:
- A. Adjust isolators after piping system is at operating weight.
 - B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- 3.07 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide equipment labels, warning signs and labels, pipe labels, valve tags, warning tags as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. A13.1: Scheme for the identification of Piping Systems

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Sustainable Design Submittals.
- B. Product Data: For each type of product indicated.
- C. Samples: For color, letter style, and graphic representation required for each identification material and device.
- D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- E. Valve numbering scheme.
- F. Valve Schedules: For each piping system to include in maintenance manuals.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sustainability Standards Certifications.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS:

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch (0.8-mm), stainless steel, 0.025-inch (0.64-mm), aluminum, 0.032-inch (0.8-mm) or anodized aluminum, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White
4. Maximum Temperature: Able to withstand temperatures up to 160 degrees F (71 degrees C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
 - D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS:

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black
- C. Background Color: Yellow.
- D. Maximum Temperature: Able to withstand temperatures up to 160 degrees F (71 degrees C).
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

2.03 PIPE LABELS:

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping. At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

2.04 STENCILS:

- A. Stencils for Piping:
 - 1. Lettering Size: Size letters according to ASME A13.1 for piping. At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.
 - 2. Stencil Material: Fiberboard or metal
 - 3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 4. Identification Paint: Exterior, alkyd enamel or acrylic enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.05 VALVE TAGS:

- A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
 - 1. Tag Material: Brass, 0.032-inch (0.8-mm), stainless steel, 0.025-inch (0.64-mm), aluminum, 0.032-inch (0.8-mm), or anodized aluminum, 0.032-inch (0.8-mm)

minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.06 WARNING TAGS:

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches (100 by 178 mm).

2. Fasteners: Brass grommet and wire or Reinforced grommet and wire or string.

3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 GENERAL INSTALLATION REQUIREMENTS:

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.03 EQUIPMENT LABEL INSTALLATION:

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION:

- A. Piping Color Coding: Painting of piping is specified in Section 09 96 00.
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1,[with painted, color-coded bands or rectangles] on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Pipe Label Color Schedule:
 - 1. Low-Pressure Compressed Air Piping:
 - a. Background: Safety blue
 - b. Letter Colors: White
 - 2. High-Pressure Compressed Air Piping:
 - a. Background: Safety blue
 - b. Letter Colors: White.

3. Domestic Water Piping
 - a. Background: Safety green
 - b. Letter Colors: White
4. Sanitary Waste and Storm Drainage Piping:
 - a. Background Color: Safety black
 - b. Letter Color: White.

3.05 VALVE-TAG INSTALLATION:

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 1. Valve-Tag Size and Shape:
 - a. Cold Water: 2 inches (50 mm), round or square.
 - b. Hot Water: 2 inches (50 mm), round or square.
 - c. Low-Pressure Compressed Air: 2 inches (50 mm), round or square.
 - d. High-Pressure Compressed Air: 2 inches (50 mm), round or square.
 2. Valve-Tag Colors:
 - a. Cold Water: Natural
 - b. Hot Water: Natural
 - c. Low-Pressure Compressed Air: Natural
 - d. High-Pressure Compressed Air: Natural
 3. Letter Colors:
 - a. Cold Water: White
 - b. Hot Water: White
 - c. Low-Pressure Compressed Air: White

d. High-Pressure Compressed Air: White

3.06 WARNING-TAG INSTALLATION:

- A. Write required message on, and attach warning tags to, equipment and other items where required.

3.07 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 07 19

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide the following plumbing piping services as indicated and in compliance with Contract Documents.
 - 1. Domestic cold-water piping
 - 2. Domestic hot-water piping
 - 3. Domestic recirculating hot-water piping
 - 4. Sanitary waste piping exposed to freezing conditions
 - 5. Storm-water piping exposed to freezing conditions
 - 6. Roof drains and rainwater leaders
 - 7. Supplies and drains for handicap-accessible lavatories and sinks

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 2. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - 3. C195: Standard Specification for Mineral Fiber Thermal Insulating Cement
 - 4. C196: Standard Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement
 - 5. C449: Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
 - 6. C450: Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
 - 7. C534: Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

8. C547: Standard Specification for Mineral Fiber Pipe Insulation
 9. C552: Standard Specification for Cellular Glass Thermal Insulation.
 10. C585: Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
 11. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
 12. C871: Standard Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
 13. C1126: Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
 14. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
 15. C1427: Standard Specification for Extruded Preformed Flexible Cellular Polyolefin Thermal Insulation in Sheet and Tubular Form
 16. D1784: Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
 17. E84: Standard Test Method for Surface Burning Characteristics of Building Materials
 18. E96: Standard Test Methods for Water Vapor Transmission of Materials
 19. F1249: Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor
- B. ICC Evaluation Services (ICC-ES):
1. A117.1: Accessible and Usable Buildings and Facilities
- C. Military and Government Specs & Standards (Naval Publications and Form Center) (NFPC):
1. MIL-A-3316C: Adhesives, Fire-Resistant, Thermal Insulation
 2. MIL-C-20079H: Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass
 3. MIL-PRF-19565C: Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.
- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 - 2. Jacket Materials for Pipe: 12 inches long by NPS 2.
 - 3. Sheet Jacket Materials: 12 inches square.
 - 4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.
- E. Qualification Data: For qualified Installer.
- F. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- G. Field quality-control reports.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- C. Fire-Test Response Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.
- D. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of mechanical insulation products, of types and sizes required, whole products have been in satisfactory use in similar service for not less than 3 years.
- E. IECC Compliance: Insulation applied to plumbing services shall comply with International Energy Conservation Code (IECC) with regard to insulation performance, thickness, and sealing.
- F. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.
- C. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

- D. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.07 COORDINATION:

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29.
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.08 SCHEDULING:

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS:

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Manufacturers:

- a. Industrial Insulation Group (The); Thermo-12 Gold
2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.

1. Manufacturers:

- a. Cell-U-Foam Corporation; Ultra-CUF
- b. Pittsburgh Corning Corporation; Foamglas Super K
2. Block Insulation: ASTM C552, Type I.
3. Special-Shaped Insulation: ASTM C552, Type III.
4. Board Insulation: ASTM C552, Type IV.
5. Preformed Pipe Insulation without jacket: Comply with ASTM C552, Type II, Class 1
6. Preformed Pipe Insulation with Factory-Applied ASJ jacket: Comply with ASTM C552, Type II, Class 2.
7. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
8. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.
1. Manufacturers:
 - a. Aeroflex USA Inc.; Aerocel
 - b. Armacell LLC; AP Armaflex
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180
- I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For equipment applications, provide insulation with factory applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Manufacturers:
 - a. Schuller (formerly Manville Corp.)
 - b. Owens-Corning Fiberglas Corp.
 - c. Certain Teed Corp.
 - d. Knauf Fiber Glass
 - e. Manson
 - f. Armstrong World Industries, Inc.
 - g. Pittsburgh Corning Corp.
 - h. Rubatex Corp.
- J. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.
1. Manufacturers:
 - a. Schuller (formerly Manville Corp.)
 - b. Owens-Corning Fiberglas Corp.
 - c. Certain Teed Corp.
 - d. Knauf Fiber Glass
 - e. Manson

- f. Armstrong World Industries, Inc.
 - g. Pittsburgh Corning Corp.
 - h. Rubatex Corp.
- 2. Type I, 850 degrees F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 degrees F is 0.29 Btu x in./h x sq. ft. x degrees F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers:
 - a. Schuller (formerly Manville Corp.)
 - b. Owens-Corning Fiberglas Corp.
 - c. Certain Teed Corp
 - d. Knauf Fiber Glass
 - e. Manson
 - f. Armstrong World Industries, Inc.
 - g. Pittsburgh Corning Corp.
 - h. Rubatex Corp.
- L. Phenolic: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C1126.
 - 1. Manufacturers:
 - a. Owens-Corning
 - b. Knauf North America
 - 2. Preformed Pipe Insulation: Type III, with factory-applied ASJ.
 - 3. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.

4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- M. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1, for tubular materials.
1. Manufacturers:
 - a. Owens-Corning
- N. Polyurethane Foam (BNR Demonstration Facility Only):
1. 90 percent minimum close cell content; initial thermal conductivity of 0.16 Btu in./hour.Ft² F; minimum density of 2.0 lbs/cubic foot and minimum thickness of 1 inch. Jacket to be minimum of 0.125 inches HDPE meeting requirements of ASTM D1248, Type 3, Class C.
 2. Manufacturer:
 - a. Permapipe; model XTru-Therm.
 3. Install in accordance with manufacturer's instructions.
- 2.02 INSULATING CEMENTS:
- A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
 - B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
 - C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
- 2.03 ADHESIVES:
- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
 - B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 degrees F.
 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-97
 - b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93
 - c. Marathon Industries, Inc.; 290
 - d. Mon-Eco Industries, Inc.; 22-30

- e. Vimasco Corporation; 760
- C. Cellular-Glass, Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-96
 - b. Foster Products Corporation, H. B. Fuller Company; 81-33
- D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Manufacturers:
 - a. Aeroflex USA Inc.; Aeroseal
 - b. Armacell LCC; 520 Adhesive
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75
 - d. RBX Corporation; Rubatex Contact Adhesive
- E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-82
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80
 - d. Marathon Industries, Inc.; 225
 - e. Mon-Eco Industries, Inc.; 22-25
- F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-82
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80
 - d. Marathon Industries, Inc.; 225

- e. Mon-Eco Industries, Inc.; 22-25
- G. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Manufacturers:
 - a. Dow Chemical Company (The); 739, Dow Silicone
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive
 - c. P.I.C. Plastics, Inc.; Welding Adhesive
 - d. Red Devil, Inc.; Celulon Ultra Clear
 - e. Speedline Corporation; Speedline Vinyl Adhesive
- 2.04 MASTICS AND COATINGS:
 - A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - B. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-30
 - b. Foster Products Corporation, H. B. Fuller Company; 30-35
 - c. ITW TACC, Division of Illinois Tool Works; CB-25
 - d. Marathon Industries, Inc.; 501
 - e. Mon-Eco Industries, Inc.; 55-10
 - 2. Water-Vapor Permeance: ASTM F1249, 0.05 perm at 35-mil dry film thickness.
 - a. Service Temperature Range: 0 to 180 degrees F.
 - b. Solids Content: ASTM D1644, 44 percent by volume and 62 percent by weight.
 - c. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Manufacturers:

- a. Childers Products, Division of ITW; Encacel
- b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96
- c. Marathon Industries, Inc.; 570
- d. Mon-Eco Industries, Inc.; 55-70

2. Water-Vapor Permeance: ASTM F1249, 0.05 perm at 30-mil dry film thickness.

3. Service Temperature Range: Minus 50 to plus 220 degrees F.

4. Solids Content: ASTM D1644, 33 percent by volume and 46 percent by weight.

5. Color: White.

2.05 LAGGING ADHESIVES:

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Manufacturers:

- a. Childers Products, Division of ITW; CP-52
- b. Foster Products Corporation, H. B. Fuller Company; 81-42
- c. Marathon Industries, Inc.; 130
- d. Mon-Eco Industries, Inc.; 11-30
- e. Vimasco Corporation; 136

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.

3. Service Temperature Range: Minus 50 to plus 180 degrees F.

4. Color: White.

2.06 SEALANTS

A. Joint Sealants:

1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45
 - c. Marathon Industries, Inc.; 405
 - d. Mon-Eco Industries, Inc.; 44-05
 - e. Pittsburgh Corning Corporation; Pittseal 444
 - f. Vimasco Corporation; 750
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 degrees F.
5. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76-8
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44
 - c. Marathon Industries, Inc.; 405
 - d. Mon-Eco Industries, Inc.; 44-05
 - e. Vimasco Corporation; 750
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: White.

2.07 REMOVABLE INSULATION JACKETS

A. Manufacturers:

1. Childers
2. Ceel-Co

- B. Jackets for Piping Insulation: ASTM C921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.
- C. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
- D. Where piping is specified to be exposed in finished area all insulated piping shall have PVC jacketing and fitting covers as manufactured by Ceel-Co 550Z with a 25/50 flame/smoke rating not less than 15 mil thick, suitable and ready to accept a final painted finish.
- E. Jacketing Material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

2.08 FACTORY-APPLIED JACKETS:

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C1136, Type II.
- 2.09 FIELD-APPLIED FABRIC-REINFORCING MESH:
- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
 - B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
- 2.10 FIELD-APPLIED CLOTHS:
- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.
- 2.11 FIELD-APPLIED JACKETS:
- A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
 1. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - a. Manufacturers:
 - (1) Johns Manville; Zeston
 - (2) P.I.C. Plastics, Inc.; FG Series
 - (3) Proto PVC Corporation; LoSmoke
 - (4) Speedline Corporation; SmokeSafe
 - b. Adhesive: As recommended by jacket material manufacturer.
 - c. Color: White.
 - d. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - (1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - e. Factory-fabricated tank heads and tank side panels.

2. Metal Jacket:

a. Manufacturers:

- (1) Childers Products, Division of ITW; Metal Jacketing Systems
- (2) PABCO Metals Corporation; Surefit (Dewatering only)
- (3) RPR Products, Inc.; Insul-Mate (Special order required)

b. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

- (1) Factory cut and rolled to size.
- (2) Finish and thickness are indicated in field-applied jacket schedules.
- (3) Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and Kraft paper.
- (4) Moisture Barrier for Outdoor Applications: 2.5-mil-thick Polysurlyn.
- (5) Factory-Fabricated Fitting Covers:
 - (a) Same material, finish, and thickness as jacket.
 - (b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - (c) Tee covers.
 - (d) Flange and union covers.
 - (e) End caps.
 - (f) Beveled collars.
 - (g) Valve covers.
 - (h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

c. Stainless-Steel Jacket: ASTM A167 or ASTM A240.

- (1) Factory cut and rolled to size.
- (2) Material, finish, and thickness are indicated in field-applied jacket schedules.

- (3) Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and Kraft paper.
- (4) Moisture Barrier for Outdoor Applications: 2.5-mil-thick Polysurlyn.
- (5) Factory-Fabricated Fitting Covers:
 - (a) Same material, finish, and thickness as jacket.
 - (b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - (c) Tee covers.
 - (d) Flange and union covers.
 - (e) End caps.
 - (f) Beveled collars.
 - (g) Valve covers.
 - (h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- 3. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
 - a. Manufacturers:
 - (1) Pittsburgh Corning Corporation; Pittwrap
 - (2) Polyguard; Insulrap No Torch 125

2.12 TAPES:

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Manufacturers:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835
 - b. Compac Corp.; 104 and 105
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ

2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Manufacturers:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827
 - b. Compac Corp.; 110 and 111
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ
 2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555
 - b. Compac Corp.; 130
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape
 - d. Venture Tape; 1506 CW NS

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800
 - b. Compac Corp.; 120
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF
 - d. Venture Tape; 3520 CW
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.13 SECUREMENTS:

A. Bands:

1. Manufacturers:
 - a. Childers Products; Bands
 - b. PABCO Metals Corporation; Bands (Dewatering only)
 - c. RPR Products, Inc.; Bands (Special order required)
2. Stainless Steel: ASTM A240, Type 304; 0.015 inch thick, 3/4 inch wide with wing seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers:
 - (1) AGM Industries, Inc.; CWP-1
 - (2) GEMCO; CD
 - (3) Midwest Fasteners, Inc.; CD
 - (4) Nelson Stud Welding; TPA, TPC, and TPS
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Manufacturers:
 - (1) AGM Industries, Inc.; CWP-1
 - (2) GEMCO; Cupped Head Weld Pin
 - (3) Midwest Fasteners, Inc.; Cupped Head
 - (4) Nelson Stud Welding; CHP
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers:
 - (1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T
 - (2) GEMCO; Perforated Base
 - (3) Midwest Fasteners, Inc.; Spindle
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

- c. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- 4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers:
 - (1) GEMCO; Nylon Hangers
 - (2) Midwest Fasteners, Inc.; Nylon Insulation Hangers
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- 5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers:
 - (1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA
 - (2) GEMCO; Press and Peel
 - (3) Midwest Fasteners, Inc.; Self Stick
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

- d. Adhesive-backed base with a peel-off protective cover.
- 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Manufacturers:
 - (1) AGM Industries, Inc.; RC-150
 - (2) GEMCO; R-150
 - (3) Midwest Fasteners, Inc.; WA-150
 - (4) Nelson Stud Welding; Speed Clips
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - (1) GEMCO
 - (2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
 - 1. Manufacturers:
 - a. C & F Wire
 - b. Childers Products
 - c. PABCO Metals Corporation
 - d. RPR Products, Inc.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

2.14 PROTECTIVE SHIELDING GUARDS:

A. Protective Shielding Pipe Covers,:

1. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures,:

1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.15 CORNER ANGLES:

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A167 or ASTM A240, Type 304 or 316.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140

and 300 degrees F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 degrees F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS:

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
 - B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
 - C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
 - D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
 - E. Install multiple layers of insulation with longitudinal and end seams staggered.
 - F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
 - G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.
 - H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
 - I. Install insulation with least number of joints practical.
 - J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices

2. Testing agency labels and stamps
3. Nameplates and data plates
4. Cleanouts

3.04 PENETRATIONS:

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 07 84 00 for firestopping and fire-resistive joint sealers.
 - F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 00.
- 3.05 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION:
- A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area of tank and vessel surfaces.
 - 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 - 3. Protect exposed corners with secured corner angles.
 - 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
 - d. Do not overcompress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

- h. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 - i. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
 - j. Stagger joints between insulation layers at least 3 inches.
 - k. Install insulation in removable segments on equipment access doors, maintenance holes, handholes, and other elements that require frequent removal for service and inspection.
 - l. Bevel and seal insulation ends around maintenance holes, handholes, ASME stamps, and nameplates.
 - m. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
5. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
- a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 - b. Seal longitudinal seams and end joints.
6. Insulation Installation on Pumps:
- a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 - b. Fabricate boxes from galvanized steel or aluminum, at least 0.040 inch thick.

- c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.
- 7. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.
- 8. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
- 9. Do not apply insulation to equipment while hot.
- 10. Apply insulation using staggered joint method and double layer construction. Apply each layer of insulation separately.
- 11. Provide removable insulation sections with aluminum jacket and stainless steel bands to cover parts of equipment which must be opened for maintenance; include metal vessel covers, fasteners, flanged, frames and accessories.

3.06 GENERAL PIPE INSULATION INSTALLATION:

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.07 CALCIUM SILICATE INSULATION INSTALLATION:

A. Insulation Installation on Domestic Water Boiler Breechings:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.08 INSTALLATION OF CELLULAR-GLASS INSULATION:

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.09 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION:

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 3.10 INSTALLATION OF MINERAL-FIBER INSULATION:
- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
 4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.11 INSTALLATION OF PHENOLIC INSULATION:

A. General Installation Requirements:

1. Secure single-layer insulation with stainless steel bands at 12-inch intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 INSTALLATION OF POLYOLEFIN INSULATION:

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 FIELD-APPLIED JACKET INSTALLATION:

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.
- 3.14 FINISHES:
- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 99 00.
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.
- 3.15 FIELD QUALITY CONTROL:
- A. Owner will engage a qualified testing agency to perform tests and inspections.
- B. Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.

- E. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- F. All insulation applications will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.16 EQUIPMENT INSULATION SCHEDULE:

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. Provide equipment insulation as follows:

Equipment	Material	Thickness (inches)
Water-To-Water Domestic Hot Water Generator	Rigid Cellular Glass	2-1/2
	Mineral-Fiber Board	2
Steam-To-Water Domestic Hot Water Generator	Rigid Cellular Glass	3
	Mineral-Fiber Board	2
Domestic Water Pump	Rigid Cellular Glass	3
	Mineral-Fiber Board	2
Domestic Hot Water Pump	Rigid Cellular Glass	2
	Mineral-Fiber Board	1
Domestic Hot Water Storage Tank	Rigid Cellular Glass	4
	Mineral-Fiber Board	3
Filter Housing	Rigid Cellular Glass	3
	Mineral-Fiber Board	2

3.17 PIPING INSULATION SCHEDULE, GENERAL:

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.

2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 INDOOR PIPING INSULATION SCHEDULE:

- A. Provide indoor piping insulation as follows:

Piping Service	Pipe Size	Thickness (inches)	Material
Domestic Cold Water	All	1	Mineral Fiber
Domestic Hot Water & Circulation	1-1/2 inches and Smaller	1	Mineral Fiber
Domestic Hot Water & Circulation	2 inches and Larger	1-1/2	Mineral Fiber
Roof Drain & Overflow	All	1	Mineral Fiber
Roof Drain & Overflow Drain Bodies	All	1-1/2	Mineral Fiber
Exposed Piping for Fixtures for People with Disabilities (Provide Flexible Elastometric)	All	1/2	Mineral Fiber
Sanitary Waste Piping Where Heat Tracing is Installed	All	1-1/2	Mineral Fiber
Condensate	All	1	Mineral Fiber
Hot Service Vents	All	1	Mineral Fiber

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE:

- A. Provide outdoor, above ground piping insulation as follows:

Piping Service	Pipe Size	Cellular Glass Thickness
Domestic Cold Water	All	2 inches
Domestic Hot Water & Circulation	All	2 inches
Sanitary Waste & Vent	All	1-1/2 inches

3.20 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

- A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.
- B. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches thick.
- C. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

3.21 INDOOR, FIELD-APPLIED JACKET SCHEDULE:

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed:
 - 1. None.
- D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 - 1. PVC: 20 mils thick.
 - 2. Painted Aluminum, Smooth: 0.020 inch thick.
 - 3. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.016 inch thick.
- E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger than 72 Inches:
 - 1. Painted Aluminum, Smooth: 0.032 inch thick.
 - 2. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.020 inch thick.
- F. Piping, Concealed:
 - 1. None.
- G. Piping, Exposed:
 - 1. PVC: 30 mils thick.

3.22 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE:

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed:
 - 1. PVC: 20 mils thick.
 - 2. Painted Aluminum, Smooth: 0.020 inch thick.

3. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.016 inch thick.
- D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 1. Painted Aluminum, Smooth: 0.020 inch thick.
 2. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.016 inch thick.
- E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger than 72 Inches:
 1. Painted Aluminum, Smooth: 0.032 inch thick.
 2. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.020 inch thick.
- F. Piping, Concealed:
 1. PVC: 20 mils thick.
 2. Painted Aluminum, Smooth: 0.020 inch thick.
 3. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.016 inch thick.
- G. Piping, Exposed:
 1. Painted Aluminum, Smooth: 0.032 inch thick.
 2. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Corrugated: 0.020 inch thick.
- 3.23 UNDERGROUND, FIELD-APPLIED INSULATION JACKET:
 - A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.
- 3.24 CLOSEOUT ACTIVITIES:
 - A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 22 14 13

STORM DRAINAGE PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide storm drainage piping as indicated and in compliance with Contract Documents.
 - 1. Metal roof drain piping
 - 2. Miscellaneous storm drainage piping specialties
 - 3. Cleanouts
 - 4. Groundwater underdrain piping

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. A112.6.4: Roof, Deck and Balcony Drains
 - 2. A112.36.2M: Cleanouts
- B. ASTM International (ASTM):
 - 1. A48: Specification for Gray Iron Castings
 - 2. A74: Standard Specification for Cast Iron Soil Pipe and Fittings
 - 3. A888: Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
- C. Cast Iron Soil Pipe Institute (CISPI):
 - 1. 301: Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS:

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with requirements in Table 22 14 13-1 for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 METAL ROOF DRAIN PIPING:

- A. Hubless, Cast-Iron Soil Pipe and Fittings:
 - 1. See Division 40 for pipe and fitting specifications.
 - 2. Pipe and Fittings: ASTM A888 or CISPI 301.
 - 3. Heavy-Duty, Hubless-Piping Couplings:
 - a. Standards: ASTM C1277 and ASTM C1540
 - b. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
 - c. Manufacturers:
 - (1) ANACO-Husky
 - (2) Dallas Specialty
 - (3) Fernco Inc.
 - (4) MIFAB, Inc. (Dewatering only)

2.03 CLEANOUTS:

- A. Cast-Iron Exposed Cleanouts:

1. Provide threaded pipe cap
2. Size: Same as connected branch

2.04 SPECIALTY PIPE FITTINGS:

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Shielded, Non-pressure Transition Couplings:
 - a. Manufacturers:
 - (1) ANACO-Husky
 - (2) Dallas Specialty
 - (3) Fernco Inc.
 - (4) MIFAB, Inc. (Dewatering only)
 - b. Standard: ASTM C1460
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. End Connections: Same size as and compatible with pipes to be joined.
3. Pressure Transition Couplings:
 - a. Manufacturers:
 - (1) ANACO-Husky
 - (2) Dallas Specialty
 - (3) Fernco Inc.
 - (4) MIFAB, Inc. (Dewatering only)
 - b. Standard: AWWA C219
 - c. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - d. Center-Sleeve Material: Manufacturer's standard.

- e. Gasket Material: Natural or synthetic rubber.
- f. Metal Component Finish: Corrosion-resistant coating or material.

PART 3 - EXECUTION

3.01 EARTHWORK:

- A. Excavating, trenching, and backfilling are specified in Section 31 23 00.

3.02 INSTALLATION:

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 - 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 - 2. Install expansion joints, if indicated, in roof drain outlets.
 - 3. Position roof drains for easy access and maintenance.
- B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
- C. Install downspout boots at grade with top 12 inches above grade. Secure to building wall.
- D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- E. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate cleanouts at base of each vertical storm piping conductor.
- F. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- G. Install test tees in vertical conductors and near floor.

- H. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- I. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- J. Assemble channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
- K. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.
 - 1. Comply with requirements in Section 07 84 00.

3.03 CONNECTIONS:

- A. Comply with requirements for piping specified in Section 22 14 13. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Join perforated PE pipe and fittings with couplings according to ASTM D3212 with loose banded, coupled, or push-on joints.
- C. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.
- D. Connect low elevations of underslab subdrainage to stormwater sump pumps in maintenance holes. Comply with requirements for sump pumps specified in Section 22 11 23.

3.04 CLEANOUT INSTALLATION:

- A. Cleanouts for Underslab Subdrainage:
 - 1. Install cleanouts and riser extensions from piping to top of grade. Locate cleanouts at beginning of piping run as indicated on plans. Install fittings so cleanouts open in direction of flow in piping.
 - 2. Use NPS 12 cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

3.05 FLASHING INSTALLATION:

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.

- D. Secure flashing into sleeve and specialty clamping ring or device.

3.06 PROTECTION:

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.07 FIELD QUALITY CONTROL:

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.
3. Drain piping will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

3.08 CLEANING:

1. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

3.09 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

Table 22 14 13-1 Plumbing Storm Drainage Piping Schedule							
Service	Size (in)	Pipe Matl	Fittings	Gasket	Joint Type	Location	Remarks
Storm Drain	All	CAST IRON, CISPI 301	Cast-Iron	Neoprene rubber with stainless clamp/shield	No-Hub CISPI 310	All	For process areas typically use 3" and greater Class 53 DIP ceramic epoxy lined or less than 3" 316 SS sched 40
Storm Drain	All	CAST IRON, CISPI 301	Cast-Iron	Neoprene rubber with stainless clamp/shield	No-Hub CISPI 310	Inside Exposed, Encased, Buried within building footprint	

END OF SECTION

SECTION 22 14 23

STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide storm drainage piping specialties as indicated and in compliance with Contract Documents.
 - 1. Metal roof drains
 - 2. Miscellaneous storm drainage piping specialties
 - 3. Backwater valves

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. A112.6.4: Roof, Deck and Balcony Drains
 - 2. A112.14.1: Backwater Valves
 - 3. A112.36.2M: Cleanouts
- B. ASTM International (ASTM):
 - 1. A48: Specification for Gray Iron Castings.
 - 2. A74: Standard Specification for Cast Iron Soil Pipe and Fittings
 - 3. A888: Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
- C. Cast Iron Soil Pipe Institute (CISPI):
 - 1. 301: Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 METAL ROOF DRAINS:

- A. American Iron and Steel (AIS) Complaint - Cast-Iron, Combination Main and Overflow, General-Purpose Roof Drains:

- 1. Manufacturers:

- a. Josam Company; Josam Division (Special order required)
 - b. Approved AIS Compliant equal

- 2. Standard: ASME A112.6.4.

- 3. Body Material: Cast iron.

- 4. Dimension of Body: Nominal 12 inch diameter.

- 5. Combination Flashing Ring and Gravel Stop: Required.

- 6. Flow-Control Weirs: Required.

- 7. Outlet: Bottom.

- 8. Outlet Type: No hub.

- 9. Extension Collars: Required.

- 10. Underdeck Clamp: Required.

11. Expansion Joint: Not required.
12. Sump Receiver Plate: Required.
13. Dome Material: Cast iron.
14. Perforated Gravel Guard: Stainless steel.
15. Vandal-Proof Dome: Required.
16. Water Dam: 2 inches high.

2.02 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES:

A. Downspout Adaptors :

1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
2. Size: Inlet size to match parapet drain outlet.

B. Cleanouts:

1. Floor Cleanouts:

a. Manufacturers:

- (1) Josam Company; Josam Division (Special order required)
- (2) Oatey (Dewatering only)
- (3) Sioux Chief Manufacturing Company, Inc.
- (4) Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
- (5) Watts Drainage Products Inc.
- (6) Zurn Plumbing Products Group; Light Commercial Operation (Dewatering only)

b. Standard: ASME A112.36.2M for adjustable housing; cast-iron soil pipe with cast-iron ferrule; heavy-duty, adjustable housing; threaded, adjustable housing cleanout.

c. Size: Same as connected branch.

d. Type: Heavy-duty, adjustable housing.

- (1) Body or Ferrule: Cast iron, unless otherwise noted on drawings.

- (2) Clamping Device: Not required.
- (3) Outlet Connection: Threaded.
- (4) Closure: Cast-iron plug.
- (5) Adjustable Housing Material: Cast iron with threads, set-screws or other device.
- (6) Frame and Cover Material and Finish: cast iron
- (7) Top Loading Classification: Heavy Duty.
- (8) Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

2. Wall Cleanouts:

a. Manufacturers:

- (1) Josam Company; Josam Division (Special order required)
- (2) MIFAB, Inc.
- (3) Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
- (4) Watts Drainage Products Inc.
- (5) Zurn Plumbing Products Group; Specification Drainage Operation (Dewatering only)

b. Standard: ASME A112.36.2M. Include wall access.

c. Size: Same as connected drainage piping.

d. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.

- (1) Closure: Countersunk or raised-head, drilled-and-threaded cast-iron plug.
- (2) Closure Plug Size: Same as or not more than one size smaller than cleanout size.
- (3) Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
- (4) Wall Access: Round, stainless-steel wall-installation frame and cover.

3. Flashing Materials

- a. Refer to Section 07 60 00 for material specification.

2.03 BACKWATER VALVES:

A. Cast-Iron, Horizontal Backwater Valves:

1. Manufacturers:

- a. MIFAB (Dewatering only)
- b. Zurn (Dewatering only)
- c. Josam Company; Josam Division (Special order required)
- d. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
- e. Watts Drainage Products Inc.

2. Standard: ASME A112.14.1.

3. Size: Same as connected piping.

4. Body Material: Cast iron.

5. Cover: Cast iron with bolted access check valve.

6. End Connections: Hub and spigot or hubless.

7. Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.

8. Extension: ASTM A74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

- 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
- 2. Install expansion joints, if indicated, in roof drain outlets.

3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

D. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.

2. Locate cleanouts at each change in direction of piping greater than 45 degrees.

3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.

4. Locate cleanouts at base of each vertical storm piping conductor.

E. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

F. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

G. Install horizontal backwater valves in floor with cover flush with floor.

H. Install drain-outlet backwater valves in outlet of drains.

I. Install test tees in vertical conductors and near floor.

J. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

K. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

1. Comply with requirements in Section 07 84 00.

3.02 CONNECTIONS:

A. Comply with requirements for piping specified in Section 22 14 13. Drawings indicate general arrangement of piping, fittings, and specialties.

3.03 FLASHING INSTALLATION:

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.

- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

3.04 PROTECTION:

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. The Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. 841: Motors
- B. National Electrical Manufacturers Association (NEMA):
 - 1. MG-1: Motors and Generators.

1.03 COORDINATION:

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS:

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS:

- A. Duty: Continuous duty at ambient temperature of 40 degrees C and at altitude of 4500 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 POLYPHASE MOTORS:

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreaseable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F.
- I. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS:

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.05 SINGLE-PHASE MOTORS:

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION

3.01 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 16

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Flexible-hose packless expansion joints.
 - 2. Alignment guides and anchors.

1.03 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 2. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 3. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
 - 4. Maintenance Data: For expansion joints to include in maintenance manuals.
- B. Quality Assurance
 - 1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.02 PACKLESS EXPANSION JOINTS

- A. Flexible-Hose Packless Expansion Joint:
 - 1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 - 2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 - 3. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
 - 4. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.

2.03 ALIGNMENT GUIDES AND ANCHORS

- A. Alignment Guides:
 - 1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
- B. Anchor Materials:
 - 1. Steel Shapes and Plates: ASTM A36/A36M.

2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.01 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install packed-type expansion joints with packing suitable for fluid service.
- C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- D. Install rubber packless expansion joints according to FSA-PSJ-703.
- E. Install grooved-joint expansion joints to grooved-end steel piping.

3.02 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install two guides on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 23 05 17

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:

- 1. Sleeves.
- 2. Stack-sleeve fittings.
- 3. Sleeve-seal systems.
- 4. Sleeve-seal fittings.
- 5. Grout.
- 6. Silicone sealants.

- B. Related Requirements:

- 1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.03 SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
- C. Informational Submittals
 - 1. Field quality-control reports.

PART 2 - PRODUCTS

2.01 SLEEVES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.
- C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.
- E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.02 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, Dura-coated or galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.03 SLEEVE-SEALING SYSTEMS

- A. Description:
 - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 2. Designed to form a hydrostatic seal of 20-psig minimum.
 - 3. Sealing Elements: High-temperature-silicone interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 - 4. Pressure Plates: Stainless steel.
 - 5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.04 SLEEVE-SEAL FITTINGS

A. Description:

1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.05 GROUT

- A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.06 SILICONE SEALANTS

- A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, use NT.
- B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.
- C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 1. Sleeves are not required for core-drilled holes.

- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 84 13 "Penetration Firestopping."

3.02 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00 "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

- B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.04 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings as new walls and slabs are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout or silicone sealant, seal space around outside of sleeve-seal fittings.

3.05 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.06 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls Above Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.
 - 2. Concrete Slabs Above Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.

3. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.

END OF SECTION

SECTION 23 05 18
ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide escutcheons and floor plates as indicated and in compliance with Contract Documents.

1.02 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.

1.03 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS:

- A. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.
- B. One-Piece, Cast-Brass Type: With chrome-plated finish and setscrew fastener.
- C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
- D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; hinge; and spring-clip fasteners.

2.02 FLOOR PLATES:

- A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with hinge with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece stainless steel with polished stainless-steel finish.
 - g. Bare Piping in Equipment Rooms: One-piece stainless steel with polished stainless-steel finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
 - D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: Split floor plate.

3.02 FIELD QUALITY CONTROL:

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

3.03 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 19

METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide meters and gauges for HVAC piping as indicated and in compliance with Contract Documents.
 - 1. Bimetallic-actuated thermometers
 - 2. Liquid-in-glass thermometers
 - 3. Duct-thermometer mounting brackets
 - 4. Thermowells
 - 5. Dial-type pressure gauges
 - 6. Gauge attachments
 - 7. Flowmeters

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.1: Unified Inch Screw Threads
 - 2. B1.20.1: Pipe Threads, General Purpose (Inch)
 - 3. B40.100: Pressure Gauges and Gauge Attachments
 - 4. B40.200: Thermometers, Direct Reading and Remote Reading

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.
- C. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.
- D. Product Certificates: For each type of meter and gauge.

- E. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.
- 1.04 SUSTAINABLE DESIGN:
 - A. Comply with the requirements specified in Section 01 81 13.01.
- 1.05 SPARE PARTS:
 - A. Comply with the requirements specified in Section 01 61 00.
- 1.06 QUALITY ASSURANCE:
 - A. Comply with the requirements specified in Section 01 43 00.
- 1.07 DELIVERY STORAGE AND HANDLING:
 - A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

- 2.01 BIMETALLIC-ACTUATED THERMOMETERS:
 - A. Manufacturers:
 - 1. Terice
 - 2. Ashcroft
 - 3. Winters
 - 4. Marsh
 - B. Standard: ASME B40.200.
 - C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch nominal diameter.
 - D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in degrees F.
 - E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
 - F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
 - G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
 - H. Window: Plain glass or plastic.
 - I. Ring: Stainless steel.

- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1 percent of scale range.

2.02 LIQUID-IN-GLASS THERMOMETERS:

- A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
 - 1. Terrice
 - 2. Ashcroft
 - 3. Winters
 - 4. Marsh
- B. Standard: ASME B40.200.
- C. Case: Cast aluminum; 6-inch nominal size.
- D. Case Form: Straight unless otherwise indicated.
- E. Tube: Glass with magnifying lens and blue or red organic liquid.
- F. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in degrees F.
- G. Window: Glass or plastic.
- H. Stem: Aluminum or brass and of length to suit installation.
 - 1. Design for Air-Duct Installation: With ventilated shroud.
 - 2. Design for Thermowell Installation: Bare stem.
- I. Connector: 3/4 inch, with ASME B1.1 screw threads.
- J. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.03 DUCT-THERMOMETER MOUNTING BRACKETS:

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.04 THERMOWELLS:

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.05 DIAL-TYPE PRESSURE GAUGES:

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:

1. Manufacturers:
 - a. Trerice
 - b. Ashcroft
 - c. Weiss
 - d. Marsh
2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Gasketed pressure relief back with solid front.

5. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
6. Diaphragm assembly for corrosive service.
7. Snubber for pulsating operation.
8. Oil filled for high vibration applications.
9. Pressure Connection: Brass, with ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
10. Movement: Mechanical, with link to pressure element and connection to pointer.
11. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
12. Pointer: Dark-colored metal.
13. Window: Glass.
14. Ring: Brass or Stainless steel.
15. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.06 GAUGE ATTACHMENTS:

- A. Snubbers: ASME B40.100, brass; ASME B1.20.1 pipe threads and piston surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of stainless-steel pipe.
- C. Valves: Brass ball, with ASME B1.20.1 pipe threads.

2.07 FLOWMETERS

- A. Turbine Flowmeters:
 1. Manufacturers:
 - a. Terice
 - b. Ashcroft
 - c. Weiss
 - d. Marsh
 2. Standard: ASME B40.100.

3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute.
5. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for water.
6. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
7. Minimum Pressure Rating: 150 psig.
8. Minimum Temperature Rating: 180 deg F.
9. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
10. Accuracy: Plus or minus 1-1/2 percent.
11. Display: Shows rate of flow, with register to indicate total volume in gallons.
12. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install thermowells with socket extending a minimum of one-third of pipe diameter and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

- H. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
 - I. Install remote-mounted pressure gauges on panel.
 - J. Install valve and snubber in piping for each pressure gauge for fluids.
 - K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
 - L. Install permanent indicators on walls or brackets in accessible and readable positions.
 - M. Install connection fittings in accessible locations for attachment to portable indicators.
 - N. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler.
 - 3. Two inlets and two outlets of each chiller.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 5. Inlet and outlet of each thermal-storage tank.
 - 6. Other locations as indicated.
 - O. Install pressure gauges in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
 - 3. Suction and discharge of each pump.
- 3.02 CONNECTIONS:
- A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.
- 3.03 ADJUSTING:
- A. After installation, calibrate meters according to manufacturer's written instructions.
 - B. Adjust faces of meters and gauges to proper angle for best visibility.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 23.12

BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide ball valves for HVAC piping as indicated and in compliance with Contract Documents.

- 1. Brass ball valves

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):

- 1. B1.20.1: Pipe Threads, General Purpose (Inch)
 - 2. B16.1: Pipe Flanges and Fittings
 - 3. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
 - 4. B16.10: Face-to-Face and End-to-End Dimensions of Valves
 - 5. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings
 - 6. B16.34: Valves – Flanged, Threaded, and Welding End
 - 7. B31.1: Power Piping
 - 8. B31.9: Building Services Piping

- B. ASTM International (ASTM):

- 1. A126: Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

- C. Manufacturers' Standardization Society (MSS):

- 1. SP-45: Bypass and Drain Connections
 - 2. SP-72: Ball Valves with Flanged for Butt-Welding Ends for General Service
 - 3. SP-110: Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

1.03 DEFINITIONS:

- A. CWP: Cold working pressure
- B. SWP: Steam working pressure

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of valve.

1.05 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.06 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.07 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.08 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, and weld ends.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
- C. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- D. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.5 for flanges on steel valves.
 - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 5. ASME B31.1 for power piping valves.
 - 6. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Refer to HVAC valve schedule articles for applications of valves.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
 - 1. Hand lever: Zinc plated carbon steel with vinyl insulator.
- H. Valves in Insulated Piping:
 - 1. Include 2-inch stem extensions.
 - 2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
 - 3. Memory stops that are fully adjustable after insulation is applied.
- I. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRASS BALL VALVES:

A. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Threaded Ends:

1. Manufacturers:
 - a. Kitz Corporation
 - b. Toyo
 - c. MAS
 - d. Nibco
 - e. Watts
2. Description:
 - a. Standard: MSS SP-110
 - b. SWP Rating: 150 psig
 - c. CWP Rating: 600 psig
 - d. Body Design: Two piece
 - e. Body Material: Forged brass
 - f. Ends: Threaded
 - g. Seats: PTFE
 - h. Stem: Brass
 - i. Ball: Chrome-plated brass
 - j. Port: Full

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION:

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements in Section 23 05 53 for valve tags and schedules.

3.03 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS:

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Threaded.
 - 3. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 4. For Steel Piping, NPS 2-1/2 to NPS 4: Threaded ends.
 - 5. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.04 CHILLED-WATER VALVE SCHEDULE:

- A. Brass ball valves, two piece, with brass trim, full port, threaded ends.

3.05 HEATING-WATER VALVE SCHEDULE:

- A. Brass ball valves, two piece, with brass trim, full port, threaded ends.

3.06 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 23.13

BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide butterfly valves for HVAC piping as indicated and in compliance with Contract Documents. The document includes building HVAC butterfly valves.
 - 1. Iron, single-flange butterfly valves
 - 2. Iron, grooved-end butterfly valves
 - 3. Chainwheels

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1: Pipe Flanges and Fittings
 - 2. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
 - 3. B16.10: Face-to-Face and End-to-End Dimensions of Valves
 - 4. B16.34: Valves – Flanged, Threaded, and Welding End
 - 5. B31.1: Power Piping
 - 6. B31.9: Building Services Piping
- B. ASTM International (ASTM):
 - 1. A126: Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - 2. A536: Standard Specification for Ductile Iron Castings
- C. American Water Works Association (AWWA):
 - 1. C606: Grooved and Shouldered Joints
- D. Manufacturers' Standardization Society (MSS):
 - 1. SP-67: Butterfly Valves

2. SP-68: High Pressure Butterfly Valves with Offset Design

1.03 DEFINITIONS:

- A. CWP: Cold working pressure
- B. EPDM: Ethylene propylene copolymer rubber

1.04 SUBMITTALS:

- A. Submit the shop drawings in accordance with Section 01 33 00.
- B. Detailed Product Data: For each type of valve.

1.05 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.06 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.07 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.08 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set butterfly valves closed or slightly open.
- C. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- D. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.1 for flanges on iron valves
 - 2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria
 - 4. ASME B31.1 for power piping valves
 - 5. ASME B31.9 for building services piping valves
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Actuator Types:
 - 1. Gear Actuator: For valves NPS 8 and larger (Manual override)
 - 2. Hand-lever: For valves NPS 6 and smaller (Manual override)
 - 3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height. Attached to all valves located higher than 7 feet.
- G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

2.02 IRON, SINGLE-FLANGE BUTTERFLY VALVES:

- A. Building Systems: Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
 - 1. Manufacturers:
 - a. Kitz Corporation
 - b. Apollo
 - c. NIBCO, Inc.

- d. Keystone
 - e. Toyo
 - f. Tyco Grinnell
 - g. MAS
 - h. DeZURIK
 - i. Watts
2. Description:
- a. Standard: MSS SP-67, Type I
 - b. CWP Rating: 200 psig
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron
 - e. Seat: EPDM
 - f. Stem: One- or two-piece stainless steel
 - g. Disc: Aluminum bronze

2.03 IRON, GROOVED-END BUTTERFLY VALVES,

A. Description:

- 1. Standard: MSS SP-67, Type I.
- 2. CWP Rating: 175 psig.
- 3. Body Material: Coated, ductile iron.
- 4. Stem: Two-piece stainless steel.
- 5. Disc: Coated, ductile iron.
- 6. Seal: EPDM.

2.04 CHAINWHEELS:

- A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
 - 1. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve. Include zinc or epoxy coating.
 - 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- D. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION:

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.
- F. Install valve tags. Comply with requirements in Section 23 05 53 for valve tags and schedules.

3.03 ADJUSTING:

- A. Adjust if required.

- B. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 23.14

CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide check valves for HVAC piping as indicated and in compliance with Contract Documents.
- B. Section Includes:
 - 1. Bronze lift check valves
 - 2. Bronze swing check valves
 - 3. Iron swing check valves

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.20.1: Pipe Threads, General Purpose
 - 2. B16.1: Pipe Flanges and Fittings
 - 3. B16.10: Face-to-Face and End-to-End Dimensions of Valves
 - 4. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings
 - 5. B16.34: Valves – Flanged, Threaded, and Welding End
- B. ASTM International (ASTM):
 - 1. A126: Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - 2. A395: Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
 - 3. A536: Standard Specification for Ductile Iron Castings
 - 4. B61: Standard Specification for Steam or Valve Bronze Castings
 - 5. B62: Standard Specification for Composition Bronze or Ounce Metal Castings

C. American Water Works Association (AWWA):

1. C606: Grooved and Shouldered Joints

D. Manufacturers' Standardization Society (MSS):

1. SP-45: Bypass and Drain Connections

2. SP-71: Gray Iron Swing Check Valves, Flanged and Threaded Ends

3. SP-80: Bronze Gate, Globe, Angle, and Check Valves

4. SP-125: Check Valves: Gray Iron and Ductile Iron, In-Line, Spring-Loaded, Center-Guided

1.03 DEFINITIONS:

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.04 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Product Data: For each type of valve.

1.05 SUSTAINABLE DESIGN:

A. Comply with the requirements specified in Section 01 81 13.01.

1.06 SPARE PARTS:

A. Comply with the requirements specified in Section 01 61 00.

1.07 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

1.08 DELIVERY STORAGE AND HANDLING:

A. Comply with the requirements specified in Section 01 66 10.

B. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Block check valves in either closed or open position.
- C. Use the following precautions during storage:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- D. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves
 2. ASME B16.1 for flanges on iron valves
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRONZE LIFT CHECK VALVES:

- A. Bronze Lift Check Valves with Bronze Disc, Class 125:
1. Manufacturers:
 - a. Toyo
 - b. Jenkins Valves

- c. Crane
 - d. Kitz Corporation
 - e. Milwaukee Valve Company
 - f. Watts
 - g. NIBCO
2. Description:
- a. Standard: MSS SP-80, Type 1
 - b. CWP Rating: 200 psig
 - c. Body Design: Vertical flow
 - d. Body Material: ASTM B61 or ASTM B62, bronze
 - e. Ends: Threaded
 - f. Disc: Bronze

2.03 BRONZE SWING CHECK VALVES:

A. Bronze Swing Check Valves with Bronze Disc, Class 125:

1. Manufacturers:
- a. Toyo
 - b. Jenkins Valves
 - c. Crane
 - d. Kitz Corporation
 - e. Milwaukee Valve Company
 - f. Watts
 - g. NIBCO
2. Description:
- a. Standard: MSS SP-80, Type 3
 - b. CWP Rating: 200 psig

- c. Body Design: Horizontal flow
- d. Body Material: ASTM B62, bronze
- e. Ends: Threaded
- f. Disc: Bronze

2.04 IRON SWING CHECK VALVES:

A. Iron Swing Check Valves with Metal Seats, Class 125:

1. Manufacturers:

- a. Toyo
- b. Jenkins Valves
- c. Crane
- d. Kitz Corporation
- e. Milwaukee Valve Company
- f. Watts
- g. NIBCO

2. Description:

- a. Standard: MSS SP-71, Type I
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig
- c. NPS 14 to NPS 24, CWP Rating: 150 psig
- d. Body Design: Clear or full waterway
- e. Body Material: ASTM A126, gray iron with bolted bonnet
- f. Ends: Flanged
- g. Trim: Bronze
- h. Gasket: Asbestos free

B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:

1. Manufacturers:

- a. Toyo
- b. Jenkins Valves
- c. Crane
- d. Kitz Corporation
- e. Milwaukee Valve Company
- f. Watts
- g. NIBCO

2. Description:

- a. Standard: MSS SP-71, Type I
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig
- c. NPS 14 to NPS 24, CWP Rating: 150 psig
- d. Body Design: Clear or full waterway
- e. Body Material: ASTM A126, gray iron with bolted bonnet
- f. Ends: Flanged
- g. Trim: Composition
- h. Seat Ring: Bronze
- i. Disc Holder: Bronze
- j. Disc: PTFE
- k. Gasket: Asbestos free

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION:

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
 - 3. Lift Check Valves: With stem upright and plumb.
- F. Install valve tags. Comply with requirements for valve tags and schedules in Section 23 05 53.

3.03 ADJUSTING:

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS:

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
 - b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.

B. Select valves, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

3.05 CHILLED-WATER VALVE SCHEDULE:

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: Threaded ends.
2. Bronze swing check valves with bronze disc, Class 125.

B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves with metal seats, Class 125.
2. Iron, center-guided check valves metal seat, Class 125.

3.06 HEATING-WATER VALVE SCHEDULE:

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: Threaded ends.
2. Bronze swing check valves with bronze disc, Class 125.

B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves with metal seats, Class 125.
2. Iron, center-guided check valves metal seat, Class 125.

3.07 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 23.15

GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide bronze gate valves, iron gate valves and chainwheels as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.20.1: Pipe Threads, General Purpose
 - 2. B16.1: Pipe Flanges and Fittings
 - 3. B16.10: Face-to-Face and End-to-End Dimensions of Valves
 - 4. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings
 - 5. B16.34: Valves – Flanged, Threaded, and Welding End
- B. ASTM International (ASTM):
 - 1. A126: Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - 2. B62: Standard Specification for Composition Bronze or Ounce Metal Castings
- C. American Water Works Association (AWWA):
 - 1. C606: Grooved and Shouldered Joints
- D. Manufacturers' Standardization Society (MSS):
 - 1. SP-45: Bypass and Drain Connections
 - 2. SP-70: Gray Iron Gate Valves, Flanged and Threaded Ends
 - 3. SP-80: Bronze Gate, Globe, Angle, and Check Valves

1.03 DEFINITIONS:

- A. CWP: Cold working pressure.

- B. NRS: Non-rising stem.
- C. OS&Y: Outside screw and yoke.
- D. RS: Rising stem.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of valve.

1.05 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.06 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.07 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.08 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set gate valves closed to prevent rattling.
- C. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- D. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves
 - 2. ASME B16.1 for flanges on iron valves
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. RS Valves in Insulated Piping: With 2-inch stem extensions.
- H. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRONZE GATE VALVES:

- A. Bronze Gate Valves, NRS, Class 125:
 - 1. Manufacturers:
 - a. Kitz Corporation
 - b. Toyo
 - c. Jenkins Valves
 - d. Crane
 - e. Milwaukee Valve Company
 - f. Watts
 - g. NIBCO

2. Description:
 - a. Standard: MSS SP-80, Type 1
 - b. CWP Rating: 200 psig
 - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet
 - d. Ends: Threaded
 - e. Stem: Bronze
 - f. Disc: Solid wedge; bronze
 - g. Packing: Asbestos free
 - h. Handwheel: Malleable iron, bronze, or aluminum

B. Bronze Gate Valves, RS, Class 125:

1. Manufacturers:
 - a. Kitz Corporation
 - b. Toyo
 - c. Jenkins Valves
 - d. Crane
 - e. Milwaukee Valve Company
 - f. Watts
 - g. NIBCO
2. Description:
 - a. Standard: MSS SP-80, Type 1
 - b. CWP Rating: 200 psig
 - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet
 - d. Ends: Threaded
 - e. Stem: Bronze
 - f. Disc: Solid wedge; bronze

- g. Packing: Asbestos free
- h. Handwheel: Malleable iron, bronze, or aluminum

2.03 IRON GATE VALVES:

A. Iron Gate Valves, NRS, Class 125:

1. Manufacturers:

- a. Kitz Corporation
- b. Toyo
- c. Jenkins Valves
- d. Crane
- e. Milwaukee Valve Company
- f. Watts
- g. NIBCO

2. Description:

- a. Standard: MSS SP-70, Type I
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig
- c. NPS 14 to NPS 24, CWP Rating: 150 psig
- d. Body Material: ASTM A126, gray iron with bolted bonnet
- e. Ends: Flanged
- f. Trim: Bronze
- g. Disc: Solid wedge
- h. Packing and Gasket: Asbestos free

2.04 CHAINWHEELS:

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

- 1. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve. Include zinc or epoxy coating.

2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION:

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.
- F. Install valve tags. Comply with requirements in Section 23 05 53 for valve tags and schedules.

3.03 ADJUSTING:

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS:

- A. If valve applications are not indicated, use the following:
 1. Shutoff Service: Gate valves.

- B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint valve-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.
 - 7. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

3.05 CHILLED-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze valves, RS, Class 125, with threaded ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y, Class 125.

3.06 HEATING-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze valves, RS, Class 125, with threaded ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y, Class 125.

3.07 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide hangers and supports for HVAC piping and equipment as indicated and in compliance with Contract Documents.
- B. Section Includes:
 - 1. Metal pipe hangers and supports
 - 2. Trapeze pipe hangers
 - 3. Metal framing systems
 - 4. Thermal-hanger shield inserts
 - 5. Fastener systems
 - 6. Pipe stands
 - 7. Equipment supports

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. ASME Boiler and Pressure Vessel Code, Section IX
 - 2. B31.9: Building Services Piping
- B. ASTM International (ASTM):
 - 1. A36: Standard Specification for Structural Steel
 - 2. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
 - 3. A780: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

4. A1011: Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
5. B221: Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
6. C552: Standard Specification for Cellular Glass Thermal Insulation
7. C591: Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
8. C1107: Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
9. D635: Standard Test Method for Rate of Burning and/or Extent of Burning of Plastics in a Horizontal Position
10. E84: Standard Test Method for Surface Burning Characteristics of Building Materials

C. American Welding Society (AWS):

1. D1.1: Structural Welding Code

D. Metal Framing Manufacturer's Association (MFMA):

1. 4: Metal Framing Standards
2. 103: Guidelines for the Use of Metal Framing

E. Manufacturers' Standardization Society (MSS):

1. SP-58: Pipe Hangers and Supports - Materials and Design

F. Underwriters' Laboratories, Inc. (UL):

1. 94: Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.

- C. Shop Drawings: Signed and sealed by a qualified Professional Engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers
 - 2. Metal framing systems
 - 3. Pipe stands
 - 4. Equipment supports
 - D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Include design calculations for designing trapeze hangers.
 - E. Welding certificates.
- 1.04 SUSTAINABLE DESIGN:
- A. Comply with the requirements specified in Section 01 81 13.01.
- 1.05 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.06 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."
 - C. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.
- 1.07 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 43 00, to design trapeze pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.02 METAL PIPE HANGERS AND SUPPORTS:

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
- C. Copper Pipe and Tube Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.

2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.03 TRAPEZE PIPE HANGERS:

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.04 METAL FRAMING SYSTEMS:

- A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel channel with inturred lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: Hot-dip galvanized.

2.05 THERMAL-HANGER SHIELD INSERTS:

- A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.06 FASTENER SYSTEMS:

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Indoor Applications: Stainless steel
 - 2. Outdoor Applications: Stainless steel

2.07 PIPE STANDS:

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components.
- B. Compact Pipe Stand:
 - 1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate
 - 3. Hardware: Galvanized steel or polycarbonate
 - 4. Accessories: Protection pads
- C. Low-Profile, Single Base, Single-Pipe Stand:
 - 1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate
 - 3. Vertical Members: Two, galvanized steel, continuous-thread 1/2-inch rods
 - 4. Horizontal Member: Adjustable horizontal, galvanized steel pipe support channels
 - 5. Pipe Supports: Strut clamps
 - 6. Hardware: Galvanized steel
 - 7. Accessories: Protection pads
 - 8. Height: 12 inches

D. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber
3. Vertical Members: Two or more, galvanized steel channels
4. Horizontal Members: One or more, adjustable height, galvanized steel pipe support
5. Pipe Supports: Strut clamps
6. Hardware: Galvanized steel
7. Height: 36 inches

E. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.08 EQUIPMENT SUPPORTS:

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.09 MATERIALS:

- A. Aluminum: ASTM B221
- B. Carbon Steel: ASTM A1011
- C. Structural Steel: ASTM A36, carbon-steel plates, shapes, and bars; galvanized
- D. Stainless Steel: ASTM A240
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and non-metallic grout; suitable for interior and exterior applications.
1. Properties: Non-staining, non-corrosive, and non-gaseous
 2. Design Mix: 5000-psi, 28-day compressive strength

PART 3 - EXECUTION

3.01 APPLICATION:

- A. Comply with requirements in Section 07 84 for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 pounds.

3.02 HANGER AND SUPPORT INSTALLATION:

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A36, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth surface.

2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 for curbs.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- N. Insulated Piping:
 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick
 - b. NPS 4: 12 inches long and 0.06 inch thick
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS:

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS:

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.05 ADJUSTING:

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.06 PAINTING:

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 099600 Coatings for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.07 HANGER AND SUPPORT SCHEDULE:

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications:
 1. Chemical Storage

- G. Use copper-plated pipe hangers and stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
 - 3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 - 4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
 - 6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
 - 7. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
 - 8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
 - 9. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
 - 10. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
 - 11. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 - 12. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 13. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

14. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 15. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 16. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
 17. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
 18. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
 19. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
 20. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 degrees F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 degrees F piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 pounds
 - b. Medium (MSS Type 32): 1500 pounds
 - c. Heavy (MSS Type 33): 3000 pounds
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected

equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

- a. Horizontal (MSS Type 54): Mounted horizontally
 - b. Vertical (MSS Type 55): Mounted vertically
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system sections.
- R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- 3.08 CLOSEOUT ACTIVITIES:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 48

VIBRATION ISOLATION AND SEISMIC CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide vibration isolation and seismic control as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. A36: Standard Specification for Carbon Structural Steel
 - 2. E488: Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
- B. Conform to latest edition of CSA W59 for welding.
- C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - 1. Seismic Restraint Manual; Guidelines for Mechanical Systems
 - 2. HVAC Duct Construction Standards Metal and Flexible
- D. Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.03 DEFINITIONS:

- A. AHJ: Authority Having Jurisdiction
- B. EPDM: Ethylene-Propylene-Diene Monomer
- C. Withstand: Unit will remain in place without separation of any parts from the device when subjected to seismic forces specified.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Delegated Design Submittals: For each device, equipment or appurtenance provide written certification from Professional Engineer licensed in the State of Utah stating that supports systems and anchorage for equipment have been designed according to the requirements of Section 1613 of the building codes of Utah, Salt Lake City and

ASCE/SEI 7, and in accordance with Specification 01 41 20. Submit calculations stamped by a Professional Engineer licensed in the State of Utah for support systems and anchorage for wind, seismic, and all other pertinent loads.

1. Seismic-Restraint Details:

- a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
- b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
- c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
- d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

2. Seismic Qualification Certificates:

- a. For pumps, accessories, and components, from manufacturer.
 - (1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - (2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - (3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- b. For steel water storage tanks, accessories, and components, from manufacturer.
 - (1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - (2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - (3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- c. For hydronic piping, accessories, and components, from manufacturer.
 - (1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - (2) Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
- d. For air handling units and energy recovery units, accessories, and components, from manufacturer.
 - (1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - (2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - (3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- e. Hot water heaters, accessories, and components, from manufacturer.
 - (1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - (2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - (3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- f. For chillers, accessories, and components, from manufacturer.
 - (1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - (2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - (3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Shop Drawings, Vibration Isolators:

- 1. Complete set of approved shop drawings of mechanical equipment, piping, and ductwork equipment which is to be isolated.

2. Include, as a minimum, basic equipment layout, length and width, installed operating weights of equipment to be isolated and distribution of weight at isolation points.
3. Product Data:
 - a. Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.
 - b. Schedule of vibration isolator type with location and static and dynamic load on each.
 - c. Vibration Isolation Base Details:
 - (1) Detail fabrication, including anchorages and attachments to structure and to supported equipment.
 - (2) Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

D. Shop Drawings, Seismic Control Components:

1. Complete set of approved shop drawings of mechanical equipment, piping, and ductwork equipment that is to be seismically restrained.
2. Include, as a minimum, basic equipment layout, length and width, installed operating weights of equipment to be isolated and distribution of weight at isolation points.
3. Signed and sealed by a licensed Professional Engineer licensed registered in the State of Utah.
4. Calculations (including combining shear and tensile loads) to support seismic restraint designs shall be signed and sealed by a qualified registered Professional Engineer.
5. Include, as a minimum, a tabulation of design data for each snubber, including specific anchorage details.
6. Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
7. Product Data:
 - a. Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.

- b. Schedule of seismic control component type with location and static and dynamic load on each.
 - c. Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.
- E. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
- F. Certifications:
 - 1. Manufacturer's Certificate of Compliance, in accordance with Section 01 33 00.
 - 2. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 33 00.
 - 3. Welding Certificates: Copies of certificates for welding procedures and personnel.
 - 4. Manufacturer's Seismic Certification: Certification that specified equipment will withstand earthquake forces. Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 - b. Dimensioned Outline Drawing of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
- 1.05 SUSTAINABLE DESIGN:
 - A. Comply with the requirements specified in Section 01 81 13.01.
- 1.06 EXTRA MATERIALS:
 - A. Furnish extra materials described below which match products installed and that are packaged with protective covering for storage and identified with labels describing content.
 - 1. Seismic Snubber Units: Furnish replacement neoprene inserts for snubbers.
- 1.07 QUALITY ASSURANCE:
 - A. Comply with the requirements specified in Section 01 43 00.
 - B. Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

- C. Isolation materials, flexible connectors, and seismic restraints shall be same manufacturer. Select and certify using published or factory certified data.
- D. Vibration isolation and seismic restraint manufacturer shall be a member of the Vibration Isolation and Seismic Control Manufacturer's Association (VISCMA).
- E. Seismic Control:
 - 1. Designer Qualifications:
 - a. Professional Engineer registered in the State of Utah.
 - b. Minimum of 5 years' work experience certifying seismic snubber and anchorage details.
 - c. Components shall bear anchorage pre-approval "R" number, from OSHPD or other agency acceptable to AHJ, showing maximum seismic restraint ratings.

1.08 DESIGN REQUIREMENTS:

- A. Seismic Control:
 - 1. Design equipment, anchorage and support systems for vertical and lateral loading in accordance with Section 1613 of the building codes of Utah, Provo and ASCE/SEI 7.
 - 2. Provide seismic control as required to maintain integrity of mechanical piping, ductwork, and equipment installed in this project, so they will "withstand" earthquake forces.
 - 3. Design shall comply with requirements of this Specification, applicable codes, and requirements of Section 01 41 20.
 - 4. Design, size and install for equipment throughout facility, whether shown or not.
 - 5. Designed by a licensed Professional Engineer in the State of Utah.
 - 6. Seismic restraints shall conform to requirements of latest edition of SMACNA Seismic Restraint Manual.

1.09 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Mason Industries, Inc.
- B. Vibro-Acoustics
- C. Kinetics Noise Control Inc.

2.02 EQUIPMENT SCHEDULES:

- A. Refer to Drawings and/or Shop Drawings for product type and capacities.

2.03 VIBRATION ISOLATION:

A. General:

- 1. Provide for mechanical piping, ductwork, and equipment as identified by this Specification.
- 2. Select in accordance with equipment, pipe, or duct weight distribution to produce reasonably uniform deflections.
- 3. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 30 percent and 60 percent of maximum deflection.

B. Elastomeric Pad:

- 1. Oil-resistant and water-resistant elastomer or natural rubber waffle pads, arranged in single or multiple layers, molded with a nonslip pattern.
- 2. Waffle pads bonded each side of minimum 0.24 inch thick galvanized steel separator plate.
- 3. Height of waffle ribs shall not exceed 0.7 times width.
- 4. Maximum Loading: 60 psi.
- 5. Minimum Single Layer Thickness: 0.24 inches.
- 6. Separator plate of sufficient stiffness for uniform loading over pad area.
- 7. Factory cut to size that matches requirements of supported equipment.
- 8. Waffle Pad Material: Standard neoprene.
- 9. Number of Layers: As required to support equipment load; refer to manufacturer's data for load capacities.

C. Elastomeric Mount:

1. Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements.
2. Factory-drilled, encapsulated top plate for bolting to equipment.
3. Baseplate for bolting to structure.

D. Open Spring Isolator:

1. Freestanding, laterally stable, open-spring isolators.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplate:
 - a. Factory drilled for bolting to structure and bonded to 0.24 inches thick rubber isolator pad attached to baseplate underside.
 - b. Limit floor load to 100 psig.
 - c. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolator:

1. Freestanding, steel, open-spring isolators with seismic restraint.
2. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 0.24 inch thick elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and levelling bolt that acts as blocking during installation.
3. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
4. Minimum Additional Travel: 50 percent of required deflection at rated load.
5. Lateral Stiffness: 80 percent minimum of the rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- F. Elastomeric Hanger:
1. Double-deflection type.
 2. Molded, oil-resistant rubber or neoprene isolator elements bonded to steel housing.
 3. Threaded connections for hanger rods.
- G. Spring Hanger:
1. Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
 2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 3. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
 4. Minimum Additional Travel: 50 percent of required deflection at rated load.
 5. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 7. Elastomeric Element:
 - a. Molded, oil-resistant rubber or neoprene.
 - b. Steel washer-reinforced cup to support spring and bushing projecting through bottom of frame.
- H. Thrust Limit:
1. Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop.
 2. Rod and angle-iron brackets for attaching to equipment.
 3. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

4. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
5. Minimum Additional Travel: 50 percent of required deflection at rated load.
6. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
9. Coil Spring: Factory set and field adjustable.

2.04 EQUIPMENT BASES:

A. Structural Steel Base:

1. Factory-fabricated, welded, structural steel base and rail.
2. Design Requirements:
 - a. Lowest possible mounting height with not less than 1 inch clearance above floor.
 - b. Provide equipment anchor bolts and auxiliary motor slide bases or rails.
 - c. Provide supports for suction and discharge elbows for pumps.
3. Structural Steel:
 - a. Steel shapes, plates, and bars complying with ASTM A36.
 - b. Bases shall have shape to accommodate supported equipment.
4. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

B. Concrete Inertia Base:

1. Factory-fabricated, welded, structural steel base and rail ready for cast-in-place concrete.
2. Design Requirements:
 - a. Lowest possible mounting height with not less than 1 inch clearance above floor.
 - b. Provide equipment anchor bolts and auxiliary motor slide bases or rails.

- c. Provide supports for suction and discharge elbows for pumps.
- 3. Structural Steel:
 - a. Steel shapes, plates, and bars complying with ASTM A36.
 - b. Bases shall have shape to accommodate supported equipment.
- 4. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- 5. Fabrication:
 - a. Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete.
 - b. Obtain anchor-bolt templates from supported equipment manufacturer.
- 6. Concrete: 4600 psi
- C. Rooftop Isolation Rails:
 - 1. Factory-assembled, fully enclosed, insulated, airtight, and watertight curb rail designed to resiliently support equipment.
 - 2. Lower Support Assembly:
 - a. Sheet metal “Z” section containing adjustable and removable steel springs that support upper floating frame.
 - b. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind and seismic forces.
 - c. Provide means for attaching to building structure and a wood nailer for attaching roof materials.
 - d. Insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.
 - 3. Isolators:
 - a. Adjustable, restrained spring type, mounted on elastomeric vibration isolation pads.
 - b. Provide access ports, for level adjustment, with removable waterproof covers at isolator locations.
 - c. Locate so they are accessible for adjustment during the life of the installation without interfering with the integrity of the roof.

- d. Restrained Spring Isolators:
 - (1) Freestanding, steel, open-spring isolators with seismic restraint.
 - (2) Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and levelling bolt.
 - (3) Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
 - (4) Minimum Additional Travel: 50 percent of required deflection at rated load.
 - (5) Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
 - (6) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- e. Elastomeric Isolator Pads:
 - (1) Oil-resistant and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern.
 - (2) Single Layer Thickness: Minimum 0.24 inches
 - (3) Galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to size that match requirements of supported equipment.
 - (4) Material: Standard neoprene
 - (5) Number of Layers: As required to support equipment load; refer to manufacturer's data for load capacities.
- f. Snubber Bushings: All-directional, elastomeric snubber bushings at least 0.24 inches thick.
- g. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counter-flashed over roof materials.

2.05 FLEXIBLE CONNECTORS:

A. Flexible Pipe Connectors:

- 1. Braided Nonferrous: For nonferrous piping systems, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.

2. Braided Stainless Steel: For ferrous piping, provide stainless steel hose covered with Type 304 stainless steel wire braid with NPT steel nipples or 150 psi ANSI flanges, welded to hose.
3. Rubber:
 - a. Neoprene or EDPM construction consisting of multiple piles of nylon tire cord fabric and elastomer, molded and cured in hydraulic rubber presses.
 - b. Straight or elbow connector as indicated on the Drawings, rated at 120 psi at 219.2 degrees F.

B. Flexible Duct Connectors: Refer to Section 23 33 00.

2.06 SEISMIC RESTRAINTS:

- A. Resilient Isolation Washers and Bushings: One-piece, molded neoprene, having a durometer 50, plus or minus 5, with a flat washer face.
- B. Seismic Snubbers: Factory fabricated using welded structural steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
- C. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.
- D. Anchor Bolts:
 1. Seismic-rated, drill-in, and stud-wedge or female-wedge type.
 2. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.07 SHOP/FACTORY FINISHING:

- A. Manufacturer's standard paint applied to factory-assembled and factory-tested equipment, before shipping.
- B. Powder coating on springs and housings.
- C. Electro-galvanize hardware.
- D. Hot-dip galvanize metal components for exterior use.
- E. Baked enamel coat metal components for interior use.
- F. Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

A. General:

- 1. Install products in accordance with manufacturers' written instructions.
- 2. Connect wiring to isolated equipment with flexible hanging loop.
- 3. Install roof curbs, equipment supports, and roof penetrations as specified in Section 07 72 00.
- 4. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.
- 5. Locate isolation hangers as near overhead support structure as possible.

B. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by agency acceptable to authorities having jurisdiction.

C. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

D. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

E. Hangers and Supports for HVAC Piping and Equipment: Comply with requirements in Section 23 05 29 and those indicated below:

- 1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - a. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

- (1) Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - (2) Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - (3) Design seismic-restraint hangers and supports for piping and equipment.
 2. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- F. Hydronic Pumps: Comply with requirements in Section 23 21 23 and those indicated below:
1. Seismic Performance: Plumbing pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the pump will remain in place without separation of any parts from the pump when subjected to the seismic forces specified."
- G. Hydronic Tanks: Comply with requirements in Section 23 21 16 and those indicated below:
1. Elevated Tanks, Ground-Mounted tanks, and Indoor Storage Tanks:
 - a. Seismic Performance: Elevated water-storage tank, ground-mounts tanks, and indoor storage tanks, including tank shell, structural reinforcement, supports, and foundations, shall be capable of withstanding the effects of earthquake motions determined according to ASCE/SEI 7.
 - (1) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
 - c. Install tank seismic restraints on all tanks.

H. Hydronic Piping: Comply with requirements in Section 23 21 13 and those indicated below:

1. Seismic Performance: Hydronic piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Install seismic restraints on piping.

I. Metals Ducts: Comply with requirements in Section 23 31 13 and those indicated below:

1. Seismic Performance: Metal ductwork and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Install seismic restraints on ductwork.

J. Mechanical Equipment

1. In the sections below, seismic performance seismic for the mechanical equipment indicated shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. In each case, the term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Fans and Accessories: Comply with requirements in Section 23 34 00 and those indicated below:
 - a. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices.
 - b. Comply with requirements in Section 23 33 00 for flexible duct connectors.
3. Industrial Air Curtains: Comply with requirements in Section 23 34 33.16 and those indicated below:
 - a. Equipment Installation: Install air curtains with seismic-restraint devices.
 - b. Comply with requirements for hangers and supports specified in Section 23 05 29.

4. Hot Water Heating Boilers: Comply with requirements in Section 23 52 16 and those indicated below:
 - a. Equipment Installation: Mounting base to secure boiler to concrete base.
 - (1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces.
5. Air-Cooled Scroll Water Chillers: Comply with requirements in Section 23 64 23 and those indicated below:
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Equipment Installation: Install chiller units with seismic-restraint devices.
 - c. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
 - d. Install roof-mounted units on manufactured curb (unless noted otherwise on drawings) base designed to withstand, without damage to equipment, seismic force required by code.
6. Air Conditioning Equipment: Comply with requirements in Section 23 70 00 and those indicated below:
 - a. Equipment Installation: Install air conditioning equipment with seismic-restraint devices.
 - b. Comply with requirements for hangers and supports specified in Section 23 05 29.
7. Indoor, Semi-Custom Air-Handling Units: Comply with requirements in Section 23 73 13 and those indicated below:
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Equipment Installation: Install air-handling units with seismic-restraint devices.
 - c. Install floor-mounted units on 4-inch (unless noted otherwise on drawings) high concrete base designed to withstand, without damage to equipment, seismic force required by code.

8. Unit Heaters: Comply with requirements in Section 23 82 39 and those indicated below:

- a. Equipment Installation: Install unit heaters with seismic-restraint devices.
- b. Comply with requirements for hangers and supports specified in Section 23 05 29.

K. Vibration Isolations:

1. Install spring hangers without binding.
2. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

L. Equipment Bases:

1. Adjust equipment level.
2. Bases with seismic snubbers shall have snubbers located close to isolators.
3. Structural Steel Bases: Set steel bases for 1 inch clearance between housekeeping pad and base.
4. Concrete Inertial Bases:
 - a. Set concrete inertia bases for 2 inch clearance between housekeeping pad and base.
 - b. Fill concrete inertia bases, after installing base frame, with concrete; trowel to a smooth finish.

M. Flexible Connectors: Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

N. Seismic Restraint Devices:

1. Notify local representative of seismic restraint materials manufacturer prior to installing seismic restraint devices.
2. Representative of seismic restraint materials manufacturer shall provide a written report of compliance with installed equipment.
3. No rigid connections between equipment and building structure shall be made which degrades seismic restraint system herein specified.

4. Electrical conduit to restrained equipment shall be looped to allow free motion of equipment without damage to electrical wiring.
5. Install seismic snubbers on isolated equipment.
6. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
7. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
8. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers.
9. At trapeze anchor locations, shackle piping and equipment to trapeze.
10. Install resilient bolt isolation washers on equipment anchor bolts.
11. Upon completion of seismic restraint material installation and before startup of restrained equipment, all debris shall be cleaned from beneath all protected equipment, leaving equipment free to contact snubbers.

3.03 FIELD QUALITY CONTROL:

A. Testing: Conduct the following field quality-control testing:

1. Isolator deflection
2. Isolator seismic-restraint clearance
3. Snubber minimum clearances

B. Seismic Control Component Inspection:

1. Conduct periodic inspections of material installation with assistance of manufacturer's representative. Report in writing deviations from good installation practice.
2. Upon completion of seismic restraint device installation inspect completed system with assistance of manufacturer's representative. Report in writing installation errors, improperly selected snubber devices, or other fault in the system that could affect performance of the system.

C. Manufacturer's Services:

1. Provide manufacturer's representative at Site in accordance with Section 01 33 00 for installation assistance, inspection and certification of proper installation, equipment testing, and startup assistance.

2. Manufacturer's representative present at Site for minimum person-days listed below, travel time excluded:
 - a. 3 person-days for installation assistance and inspection
 - b. 1 person-day for completion of Manufacturer's Certification of Proper Installation
3. Inspection and Report:
 - a. Inspect isolated equipment after installation
 - b. Include static deflections
 - c. Submit report

3.04 ADJUSTING:

A. Vibration Isolation Devices:

1. Adjust isolators after piping systems have been filled and equipment is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height.
3. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
4. Attach thrust limits at centerline of thrust and adjust to a maximum of 6 mm movement during start and stop.
5. Adjust isolators to ensure units do not exceed rated operating deflections or bottom out under loading, and are not short circuited by other contacts or bearing points.
6. Adjust levelling devices as required to distribute loading uniformly on isolators. Shim units as required where levelling devices cannot be used to distribute loading properly.

B. Seismic Control Components:

1. Adjust snubbers according to manufacturer's written recommendations and additional corrections as required by the manufacturers' representative site visit per Paragraph 3.03.B.
2. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

3. Torque anchor bolts according to equipment manufacture's written recommendations to resist earthquake forces.

C. Cleaning:

1. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide equipment labels, warning signs and labels, pipe labels, duct labels, stencils, valve tags, warning tags as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. A13.1: Scheme for the Identification of Piping Systems

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.
- C. Samples: For color, letter style, and graphic representation required for each identification material and device.
- D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- E. Valve numbering scheme.
- F. Valve Schedules: For each piping system to include in maintenance manuals.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS:

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch or aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White
4. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 by 11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS:

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black
- C. Background Color: Yellow
- D. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 3-1/2 by 1 inch.
- F. Minimum Letter Size: 1/2 inch for viewing distances up to 48 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- G. Fasteners: Stainless-steel rivets
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

2.03 PIPE LABELS:

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.04 STENCILS:

A. Stencils for Piping:

1. Lettering Size: Size letters according to ASME A13.1 for piping
2. Stencil Material: Aluminum
3. Stencil Paint: Exterior, gloss, in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

B. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances
2. Stencil Material: Aluminum
3. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form
4. Identification Paint: Exterior, acrylic enamel. Paint may be in pressurized spray-can form

C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances
2. Stencil Material: Aluminum
3. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form

4. Identification Paint: Exterior, acrylic enamel. Paint may be in pressurized spray-can form

2.05 VALVE TAGS:

- A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware
 2. Fasteners: Brass beaded chain
- B. Valve Schedules: For each piping system, on 8-1/2 by 11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 1. Valve-tag schedule shall be included in operation and maintenance data.

2.06 WARNING TAGS:

- A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 1. Size: 3 by 5-1/4 inches minimum
 2. Fasteners: Brass grommet and wire
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE"
 4. Color: Safety-yellow background with black lettering

PART 3 - EXECUTION

3.01 PREPARATION:

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 GENERAL INSTALLATION REQUIREMENTS:

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.

- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.03 EQUIPMENT LABEL INSTALLATION:

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION:

- A. Piping Color Coding: Painting of piping is specified in Section 09 90 00.
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.

- 1. Identification Paint: Use for contrasting background
- 2. Stencil Paint: Use for pipe marking

- C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

- 1. Near each valve and control device.
- 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
- 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
- 4. At access doors, maintenance holes, and similar access points that permit view of concealed piping.
- 5. Near major equipment items and other points of origination and termination.
- 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
- 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

- E. Pipe Label Color Schedule:

- 1. Chilled-Water Piping: White letters on a safety-green background

2. Condenser-Water Piping: White letters on a safety-green background
3. Heating Water Piping: White letters on a safety-green background
4. Refrigerant Piping: White letters on a safety-purple background

3.05 DUCT LABEL INSTALLATION:

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 1. Blue: For cold-air supply ducts
 2. Yellow: For hot-air supply ducts
 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts
- B. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.
- C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.06 VALVE-TAG INSTALLATION:

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 1. Valve-Tag Size and Shape:
 - a. Chilled Water: 2 inches round
 - b. Condenser Water: 2 inches round
 - c. Refrigerant: 2 inches round
 - d. Hot Water: 2 inches round
 - e. Gas: 2 inches round
 2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background

- b. Flammable Fluids: Black letters on a safety-yellow background
- c. Combustible Fluids: White letters on a safety-brown background
- d. Potable and Other Water: White letters on a safety-green background
- e. Compressed Air: White letters on a safety-blue background

3.07 WARNING-TAG INSTALLATION:

- A. Write required message on, and attach warning tags to, equipment and other items where required.

3.08 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide testing, adjusting and balancing for HVAC as indicated and in compliance with Contract Documents.
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems
 - b. Variable air volume systems
 - 2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems
 - b. Variable-flow hydronic systems
 - c. Primary-secondary hydronic systems
 - 3. Testing, Adjusting, and Balancing Equipment:
 - a. Motors
 - b. Chillers
 - c. Boilers
 - d. Heat-transfer coils
 - 4. Testing, adjusting, and balancing existing systems and equipment
 - 5. Sound tests.
 - 6. Vibration tests.
 - 7. Duct leakage tests.
 - 8. Control system verification.

1.02 REFERENCES:

- A. Associated Air Balance Council (AABC):
 - 1. National Standards for Total System Balance
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 1. 201: Fans and Systems
- C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 90.1: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
 - 2. 111: Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
- D. National Environmental Balancing Bureau (NEBB):
 - 1. Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems
- E. Sheet Metal and Air Conditioning Contractors National Association (SMANCA):
 - 1. HVAC Systems – Duct Design
 - 2. HVAC Systems – Testing, Adjusting, and Balancing

1.03 DEFINITIONS:

- A. AABC: Associated Air Balance Council
- B. BAS: Building automation Systems
- C. NEBB: National Environmental Balancing Bureau
- D. TAB: Testing, adjusting, and balancing
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work
- F. TDH: Total dynamic head

1.04 PREINSTALLATION MEETINGS:

- A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report
 - b. The TAB plan
 - c. Needs for coordination and cooperation of trades and subcontractors
 - d. Proposed procedures for documentation and communication flow

1.05 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- B. Qualification Data: Within 90 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- C. Contract Documents Examination Report: Within 90 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- D. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- E. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- F. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- G. Certified TAB reports
- H. Sample report forms
- I. Instrument calibration reports, to include the following:
 - 1. Instrument type and make
 - 2. Serial number

3. Application
4. Dates of use
5. Dates of calibration

1.06 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.07 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.08 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

- B. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

- C. TAB Specialists Qualifications: Certified by NEBB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB as a TAB technician.

- D. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.09 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION:

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.

- i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.
2. Hydronics:
- a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning per the sequence of operation.
 - g. Shutoff and balance valves have been verified to be 100 percent open.
 - h. Pumps are started and proper rotation is verified.
 - i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - j. Variable-frequency controllers' startup is complete and safeties are verified.
 - k. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING:

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13, Section 23 07 16, and Section 23 07 19.

- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS:

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "record drawing" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 31 13.

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS:

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses, close to the fan and prior to any outlets, to obtain total airflow.

- c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
- 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
- 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
- 4. Obtain approval from Engineer of Record for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts
 - 2. Adjust submain and branch duct volume dampers for specified airflow
 - 3. Re-measure each submain and branch duct after all have been adjusted
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts
 - 2. Measure inlets and outlets airflow
 - 3. Adjust each inlet and outlet for specified airflow
 - 4. Re-measure each inlet and outlet after they have been adjusted

D. Verify Final System Conditions:

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile
4. Mark all final settings
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data
7. Record final fan-performance data

3.06 GENERAL PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS:

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.

- e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
- a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
- a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

- a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.07 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS:

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "record drawing" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 1. Check liquid level in expansion tank.
 2. Check highest vent for adequate pressure.
 3. Check flow-control valves for proper position.
 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 5. Verify that motor starters are equipped with properly sized thermal protection.

6. Check that air has been purged from the system.

3.08 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS:

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes
2. Adjust main and branch balance valves for design flow
3. Re-measure each main and branch after all have been adjusted

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals
2. Adjust each terminal to design flow

3. Re-measure each terminal after it is adjusted
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow
5. Perform temperature tests after flows have been balanced

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile
3. Mark final settings

G. Verify that memory stops have been set.

3.09 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS:

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated
2. Determine whether there is diversity in the system

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.

- (1) Position valves for full flow through coils.
 - (2) Measure flow by main flow meter, if installed.
 - (3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - (1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - (2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - (3) Convert pressure to head and correct for differences in gage heights.
 - (4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - (5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
2. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes
 - b. Adjust main and branch balance valves for design flow
 - c. Re-measure each main and branch after all have been adjusted
 3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals
 - b. Adjust each terminal to design flow
 - c. Re-measure each terminal after it is adjusted
 - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow
 - e. Perform temperature tests after flows have been balanced

4. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 5. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 6. Prior to verifying final system conditions, determine the system differential-pressure set point.
 7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hertz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
 8. Mark final settings and verify that all memory stops have been set.
 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile
 - c. Mark final settings
 10. Verify that memory stops have been set
- D. For systems with diversity:
1. Determine diversity factor.
 2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
 3. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.
 - (1) Position valves for full flow through coils.

- (2) Measure flow by main flow meter, if installed.
 - (3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - (1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - (2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - (3) Convert pressure to head and correct for differences in gage heights.
 - (4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - (5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- 4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes
 - b. Adjust main and branch balance valves for design flow
 - c. Re-measure each main and branch after all have been adjusted
- 5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hertz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile
 - c. Mark final settings
13. Verify that memory stops have been set.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS:

- A. Balance the primary circuit flow first.
- B. Balance the secondary circuits after the primary circuits are complete.

- C. Adjust pumps to deliver total design gpm.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - 1. Measure flow in main and branch pipes
 - 2. Adjust main and branch balance valves for design flow
 - 3. Re-measure each main and branch after all have been adjusted
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - 1. Measure flow at terminals
 - 2. Adjust each terminal to design flow
 - 3. Re-measure each terminal after it is adjusted

4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow
5. Perform temperature tests after flows have been balanced

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range
2. Perform temperature tests after flows have been verified

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile
3. Mark final settings

I. Verify that memory stops have been set.

3.11 PROCEDURES FOR MOTORS:

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number
2. Motor horsepower rating
3. Motor rpm
4. Phase and Hertz
5. Nameplate and measured voltage, each phase
6. Nameplate and measured amperage, each phase
7. Starter size and thermal-protection-element rating

8. Service factor and frame size

- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.12 PROCEDURES FOR CHILLERS:

- A. Balance water flow through each evaporator to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
 4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
 5. Capacity: Calculate in tons of cooling.
 6. For air-cooled chillers, verify condenser fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR BOILERS:

- A. Hydronic Boilers:
1. Measure and record entering- and leaving-water temperatures
 2. Measure and record water flow
 3. Record relief valve pressure setting

3.14 PROCEDURES FOR HEAT-TRANSFER COILS:

- A. Measure, adjust, and record the following data for each water coil:
1. Entering- and leaving-water temperature
 2. Water flow rate

3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units
4. Dry-bulb temperature of entering and leaving air
5. Wet-bulb temperature of entering and leaving air for cooling coils
6. Airflow

3.15 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 10 locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.

8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
 - a. Location.
 - b. System tested.
 - c. dBA reading
 - d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on NC worksheet with equipment on and off.

3.16 VIBRATION TESTS

- A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 25.
- B. Instrumentation:
 1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
 2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
 3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
 4. Verify calibration date is current for vibration meter before taking readings
- C. Test Procedures:
 1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
 2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.

3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.17 DUCT LEAKAGE TESTS:

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.18 CONTROLS VERIFICATION:

- A. In conjunction with system balancing, perform the following:
 1. Verify temperature control system is operating within the design limitations.
 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 3. Verify that controllers are calibrated and function as intended.
 4. Verify that controller set points are as indicated.
 5. Verify the operation of lockout or interlock systems.
 6. Verify the operation of valve and damper actuators.

7. Verify that controlled devices are properly installed and connected to correct controller.
 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.
- 3.19 TOLERANCES:
- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent
 2. Air Outlets and Inlets: Plus or minus 10 percent
 3. Heating-Water Flow Rate: Plus or minus 10 percent
 4. Cooling-Water Flow Rate: Plus or minus 10 percent
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.
- 3.20 PROGRESS REPORTING:
- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.
- 3.21 FINAL REPORT:
- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.
 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves
 2. Fan curves
 3. Manufacturers' test data
 4. Field test reports prepared by system and equipment installers
 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page
 2. Name and address of the TAB specialist
 3. Project name
 4. Project location
 5. Architect's name and address
 6. Engineer's name and address
 7. Contractor's name and address
 8. Report date
 9. Signature of TAB supervisor who certifies the report
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance
 - b. Notable characteristics of systems
 - c. Description of system operation sequence if it varies from the Contract Documents

12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers
 - b. Conditions of filters
 - c. Cooling coil, wet- and dry-bulb conditions
 - d. Face and bypass damper settings at coils
 - e. Fan drive settings including settings and percentage of maximum pitch diameter
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller
 - h. Other system operating conditions that affect performance
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows
 2. Water flow rates
 3. Duct, outlet, and inlet sizes
 4. Pipe and valve sizes and locations
 5. Terminal units
 6. Balancing stations
 7. Position of balancing devices

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

- a. Unit identification
- b. Location
- c. Make and type
- d. Model number and unit size
- e. Manufacturer's serial number
- f. Unit arrangement and class
- g. Discharge arrangement
- h. Sheave make, size in inches , and bore
- i. Center-to-center dimensions of sheave and amount of adjustments in inches
- j. Number, make, and size of belts
- k. Number, type, and size of filters

2. Motor Data:

- a. Motor make, and frame type and size
- b. Horsepower and rpm
- c. Volts, phase, and Hertz
- d. Full-load amperage and service factor
- e. Sheave make, size in inches, and bore
- f. Center-to-center dimensions of sheave and amount of adjustments in inches

3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm
- b. Total system static pressure in inches wg
- c. Fan rpm
- d. Discharge static pressure in inches wg

- e. Filter static-pressure differential in inches wg
- f. Preheat-coil static-pressure differential in inches wg
- g. Cooling-coil static-pressure differential in inches wg
- h. Heating-coil static-pressure differential in inches wg
- i. Outdoor airflow in cfm
- j. Return airflow in cfm
- k. Outdoor-air damper position
- l. Return-air damper position

F. Apparatus-Coil Test Reports:

1. Coil Data:

- a. System identification
- b. Location
- c. Coil type
- d. Number of rows
- e. Fin spacing in fins per inch
- f. Make and model number
- g. Face area in sq. ft.
- h. Tube size in NPS
- i. Tube and fin materials
- j. Circuiting arrangement

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm
- b. Average face velocity in fpm
- c. Air pressure drop in inches wg
- d. Outdoor-air, wet- and dry-bulb temperatures in degrees F

- e. Return-air, wet- and dry-bulb temperatures in degrees F
 - f. Entering-air, wet- and dry-bulb temperatures in degrees F
 - g. Leaving-air, wet- and dry-bulb temperatures in degrees F
 - h. Water flow rate in gpm
 - i. Water pressure differential in feet of head or psig
 - j. Entering-water temperature in degrees F
 - k. Leaving-water temperature in degrees F
- G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
- 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.
 - d. Capacity in Btu/h.
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in cfm.
 - i. Face area in sq. ft..
 - j. Minimum face velocity in fpm.
 - 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h.
 - b. Airflow rate in cfm.
 - c. Air velocity in fpm.
 - d. Entering-air temperature in deg F.
 - e. Leaving-air temperature in deg F.

- f. Voltage at each connection.
 - g. Amperage for each phase.
- H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification
 - b. Location
 - c. Make and type
 - d. Model number and size
 - e. Manufacturer's serial number
 - f. Arrangement and class
 - g. Sheave make, size in inches, and bore
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches
 - 2. Motor Data:
 - a. Motor make, and frame type and size
 - b. Horsepower and rpm
 - c. Volts, phase, and Hertz
 - d. Full-load amperage and service factor
 - e. Sheave make, size in inches, and bore
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches
 - g. Number, make, and size of belts
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm
 - b. Total system static pressure in inches wg
 - c. Fan rpm
 - d. Discharge static pressure in inches wg

- e. Suction static pressure in inches wg
- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number
 - b. Location and zone
 - c. Traverse air temperature in degrees F
 - d. Duct static pressure in inches wg
 - e. Duct size in inches
 - f. Duct area in square feet
 - g. Indicated airflow rate in cfm
 - h. Indicated velocity in fpm
 - i. Actual airflow rate in cfm
 - j. Actual average velocity in fpm
 - k. Barometric pressure in psig
 - J. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft

2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 1. Unit Data:
 - a. System and air-handling-unit identification
 - b. Location and zone
 - c. Room or riser served
 - d. Coil make and size
 - e. Flowmeter type
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm
 - b. Entering-water temperature in degrees F
 - c. Leaving-water temperature in degrees F
 - d. Water pressure drop in feet of head or psig
 - e. Entering-air temperature in degrees F
 - f. Leaving-air temperature in degrees F

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

- a. Unit identification
- b. Location
- c. Service
- d. Make and size
- e. Model number and serial number
- f. Water flow rate in gpm
- g. Water pressure differential in feet of head or psig
- h. Required net positive suction head in feet of head or psig
- i. Pump rpm
- j. Impeller diameter in inches
- k. Motor make and frame size
- l. Motor horsepower and rpm
- m. Voltage at each connection
- n. Amperage for each phase
- o. Full-load amperage and service factor
- p. Seal type

2. Test Data (Indicated and Actual Values):

- a. Static head in feet of head or psig
- b. Pump shutoff pressure in feet of head or psig
- c. Actual impeller size in inches
- d. Full-open flow rate in gpm
- e. Full-open pressure in feet of head or psig
- f. Final discharge pressure in feet of head or psig

- g. Final suction pressure in feet of head or psig
- h. Final total pressure in feet of head or psig
- i. Final water flow rate in gpm
- j. Voltage at each connection
- k. Amperage for each phase

M. Instrument Calibration Reports:

- 1. Report Data:
 - a. Instrument type and make
 - b. Serial number
 - c. Application
 - d. Dates of use
 - e. Dates of calibration

3.22 VERIFICATION OF TAB REPORT:

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.
- B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
 - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, Owner may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.23 ADDITIONAL TESTS:

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

3.24 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 07 13
DUCT INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide duct insulation as indicated and in compliance with Contract Documents.
 - 1. Indoor, concealed supply and outdoor air
 - 2. Indoor, exposed supply and outdoor air
 - 3. Indoor, concealed return located in unconditioned space
 - 4. Indoor, exposed return located in unconditioned space
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 7. Outdoor, concealed supply and return
 - 8. Outdoor, exposed supply and return

1.02 REFERENCES:

- A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 90.1: Energy Standard For Buildings Except Low-Rise Residential Buildings
- B. ASTM International (ASTM):
 - 1. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
 - 2. C1290: Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
 - 3. C1338: Test Method for Determining Fungi resistance of Insulation Materials and Facings
 - 4. E84: Standard Test Method for Surface Burning Characteristics of Building Materials

C. Underwriters Laboratories (UL)

1. 723: Test for Surface Burning Characteristics of Building Materials

D. Military and Government Specs & Standards:

1. MIL-A-3316C: Adhesives, Fire-Resistant, Thermal Insulation
2. MIL-A-24179A: Adhesive, Flexible Unicellular-Plastic Thermal
3. MIL-C-20079H: Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass
4. MIL-PRF-19565C: Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

E. National Fire Protection Association (NFPA):

1. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems
2. 90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- C. Field quality-control reports.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

- C. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- D. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
1. Ductwork Mockups:
 - a. One 10-foot section each of rectangular and round straight duct.
 - b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
 - c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
 - d. One rectangular and round transition fitting.
 - e. Four support hangers for round and rectangular ductwork.
 - f. Each type of damper and specialty.
 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 4. Obtain Architect's approval of mockups before starting insulation application.
 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 7. Demolish and remove mockups when directed.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.08 COORDINATION:

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29.
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.09 SCHEDULING:

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type II for sheet materials.
 - G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- 2.02 DUCT WRAP:
- A. Resin bonded fibrous glass blanket with a damage-resistant, flame retardant, reinforced aluminum foil (FRK) facing.
 - B. Duct wrap insulation is not known to contain penta-, octa, or deca-brominated diphenyl flame retardant substances, such as deca-Bromine (deca-BDE).
 - C. Certifications:
 - 1. GREENGUARD Indoor Air Quality Certified® and GREENGUARD Gold Certified
 - 2. Certified by SCS Global Services to contain a minimum of 53 percent recycled glass content, 31 percent pre-consumer and 22 percent post-consumer
 - 3. UL labeled
 - D. Duct Wrap Insulation:
 - 1. ASTM C1290, Type III, to maximum service temperature of 250 degrees°F, and ASTM C1136, Type II, facing material.
 - E. Acceptable Product: Owens Corning® SoftR® Duct Wrap FRK.
 - 1. Type 75: 0.75 lb./cu.ft. density: 1-1/2 in, 2 in, 2.2 in or 3 in thick
 - 2. Type 100: 1.0 lb./cu.ft. density: 1-1/2 in or 2 in thick
 - 3. Type 150: 1.5 lb./cu.ft. density: 1-1/2 in or 2 in thick

F. The duct wrap insulation shall consist of a blanket of glass fibers factory-laminated to a foil reinforced kraft (FRK) vapor retarder facing with a 2 in. stapling and taping flange on one edge.

G. Manufacturers:

1. Owens Corning
2. Johns Manville
3. Knauf Insulation

2.03 ADHESIVES:

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers:

- a. Foster
- b. Johns Manville

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers:

- a. Foster
- b. Johns Manville

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F.

C. Vapor-Retarder Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

2. Service Temperature Range: 0 to 180 deg F.
 3. Color: White.
- D. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below ambient services.
1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 2. Service Temperature Range: Minus 50 to plus 220 deg F.
 3. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 3. Color: White.

2.05 LAGGING ADHESIVES:

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Manufacturers:
 - a. Foster
 - b. Childers
 2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 3. Service Temperature Range: 0 to plus 180 degrees F

2.06 SEALANTS:

- A. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers:
 - a. Childers
 2. Materials shall be compatible with insulation materials, jackets, and substrates

3. Fire- and water-resistant, flexible, elastomeric sealant
4. Service Temperature Range: Minus 40 to plus 250 degrees F
5. Color: Aluminum

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.07 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.08 FIELD-APPLIED CLOTHS:

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

1. Manufacturers:
 - a. GLT Products
 - b. Childers

B. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish: Stucco embossed.
 - c. Moisture Barrier: Heat laminated 3-mil-thick, polyethylene–Surlyn, polyfilm moisture barrier.
2. Stainless-Steel Jacket: ASTM A167 or ASTM A240.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Moisture Barrier: Heat laminated 3-mil-thick, polyethylene–Surlyn, polyfilm moisture barrier.
3. Manufacturers:
 - a. Johns Manville
 - b. K-flex USA

2.09 TAPES:

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 1. Width: 3 inches.
 2. Thickness: 11.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 1. Manufacturers:
 - a. 3M

- b. Nashua
 - 2. Width: 3 inches
 - 3. Thickness: 6.5 mils
 - 4. Adhesion: 90 ounces force/inch in width
 - 5. Elongation: 2 percent
 - 6. Tensile Strength: 40 lbf/inch in width
 - 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
- 1. Width: 2 inches.
 - 2. Thickness: 6 mils.
 - 3. Adhesion: 64 ounces force/inch in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
- 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS:

A. Bands:

- 1. Manufacturers:
 - a. Johns Manville
 - b. Band-it

2. Stainless Steel: ASTM A167 or ASTM A240, Type 304 or Type 316; 0.020 inch thick, 3/4 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated.

a. Manufacturers:

- (1) GLT Products

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Manufacturers:

- (1) GLT Products

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Manufacturers:

- (1) GLT Products

- b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

- c. Spindle: Zinc-coated, low-carbon steel or Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

- d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

- a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

- b. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- 5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
- 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - b. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - c. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel
 - d. Wire: 16 gauge soft-annealed, stainless steel
 - e. Manufacturers:
 - (1) GLT Products

2.11 CORNER ANGLES:

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch , PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A167 or ASTM A240, Type 304 or Type 316.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 GENERAL INSTALLATION REQUIREMENTS:

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.04 PENETRATIONS:

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Section 07 84.
- E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 00.
- 3.05 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION:
- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.06 INSTALLATION OF MINERAL-FIBER INSULATION:

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over

the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching

staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.07 FIELD-APPLIED JACKET INSTALLATION:

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
 - D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.
- 3.08 FIRE-RATED INSULATION SYSTEM INSTALLATION:
- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
 - B. Insulate duct access panels and doors to achieve same fire rating as duct.
 - C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 84 00.
- 3.09 FINISHES:
- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 90 00 and Section 09 91 00.
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size
 - B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
 - C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
 - D. Do not field paint aluminum or stainless-steel jackets.
- 3.10 DUCT INSULATION SCHEDULE, GENERAL:
- A. Plenums and Ducts Requiring Insulation:
 1. Indoor, concealed supply and outdoor air
 2. Indoor, exposed supply and outdoor air
 3. Indoor, concealed return located in unconditioned space
 4. Indoor, exposed return located in unconditioned space

5. Indoor, concealed exhaust between isolation damper and penetration of building exterior
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior

B. Items Not Insulated:

1. Fibrous-glass ducts
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1
3. Factory-insulated flexible ducts
4. Factory-insulated plenums and casings
5. Flexible connectors
6. Vibration-control devices
7. Factory-insulated access panels and doors

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE:

A. Concealed supply-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density

B. Concealed return-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
2. Mineral-Fiber Board: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density

C. Concealed outdoor-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density
2. Mineral-Fiber Board: 2 inches thick and 1.5-lb/cu. ft. nominal density

D. Concealed exhaust-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
2. Mineral-Fiber Board: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density

- E. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 2 inches thick and 1.5-lb/cu. ft. nominal density
- F. Concealed, outdoor-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 3 inches thick and 1.5-lb/cu. ft. nominal density.
- G. Concealed, exhaust-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density
- H. Exposed supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density
- I. Exposed return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
- J. Exposed outdoor-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 2 inches thick and 1.5-lb/cu. ft. nominal density
- K. Exposed exhaust-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density
- L. Exposed, supply-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density

- M. Exposed, return-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density
- N. Exposed, outdoor-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches thick and 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 3 inches thick and 1.5-lb/cu. ft. nominal density
- O. Exposed, exhaust-air plenum insulation shall be one of the following:
 - 1. (Mineral-Fiber Blanket: 2 inches 1.5-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE:

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed: None
- D. Ducts and Plenums, Exposed:
 - 1. Aluminum, Stucco Embossed: 0.024 inch thick
 - 2. Stainless Steel, Type 304 or Type 316, Smooth 2B Finish: 0.016 inch thick

3.13 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 07 16

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide insulating HVAC equipment as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 1. A240: Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
 2. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 3. C450: Standard Practice for Fabrication of Thermal Insulating Fitting Covers to NPS Piping and Vessel Lagging
 4. C534: Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 5. C552: Standard Specification for Cellular Glass Thermal Insulation
 6. C585: Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
 7. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
 8. C871: Standard Test Methods for Chemical Analysis of Thermal Insulation materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
 9. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
 10. C1290: Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
 11. C1393: Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks

12. D1784: Standard Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds
13. E84: Standard Test Method for Surface Burning Characteristics of Building Materials
14. E96: Standard Test Methods for Water Vapor Transmission of Materials
15. F1249: Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

B. Military and Government Specs & Standards (MIL):

1. MIL-A-3316C: Adhesives, Fire-Resistant, Thermal Insulation
2. MIL-PRF-19565C: Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

C. National Fire Protection Association (NFPA):

1. 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems
2. 90B: Standard for the Installation of Warm Heating and Air-Conditioning Systems

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail removable insulation at equipment connections.
 2. Detail application of field-applied jackets.
 3. Detail application at linkages of control devices.
 4. Detail field application for each equipment type.
- D. Qualification Data: For qualified Installer.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- C. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
- D. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.08 COORDINATION:

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29.
- B. Coordinate clearance requirements with equipment Installer for equipment insulation application.
- C. Coordinate installation and testing of heat tracing.

1.09 SCHEDULING:

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

2.02 INSULATION MATERIALS:

- A. Comply with requirements in "Breeching Insulation Schedule," "Indoor Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type II for sheet materials.
 - 1. Manufacturers:
 - a. Armacell
 - b. Kflex
- G. Mineral-Fiber Blanket: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II, and ASTM C1290, Type III, with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers:
 - a. Owens Corning

- b. Johns Manville
 - c. Knauf
- H. Mineral-Fiber, Pipe and Tank: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C1393.
 - 1. Manufacturers:
 - a. Owens Corning
 - b. Johns Manville
 - c. Knauf
 - 2. Semi-rigid board material with factory-applied FSK jacket.
 - 3. Nominal density is 2.5 pounds per cubic foot or more.
 - 4. Thermal conductivity (k-value) at 100 degrees F is 0.29 Btu x in./h x sq. ft. x degrees F or less.
 - 5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.03 ADHESIVES:

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 - 1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 - 2. Wet Flash Point: Below 0 degrees F
 - 3. Service Temperature Range: 40 to 200 degrees F
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.04 LAGGING ADHESIVES:

- A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
 - 2. Service Temperature Range: 20 to plus 180 degrees F
 - 3. Color: White

2.05 SEALANTS:

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant
 - 2. Service Temperature Range: Minus 58 to plus 176 degrees F
 - 3. Color: White or gray
- C. FSK and Metal Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant
 - 2. Service Temperature Range: Minus 40 to plus 250 degrees F
 - 3. Color: Aluminum
- D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant
 - 2. Service Temperature Range: Minus 40 to plus 250 degrees F
 - 3. Color: White

2.06 FACTORY-APPLIED JACKETS:

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C1136, Type II.

2.07 FIELD-APPLIED CLOTHS:

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sided a minimum of 8 oz./sq. yd.
- B. Metal Jacket:
 1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Finish and thickness are indicated in field-applied jacket schedules
 - b. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and Kraft paper
 - c. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and Kraft paper
 - d. Factory-Fabricated Fitting Covers:
 - (1) Same material, finish, and thickness as jacket
 - (2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows
 - (3) Tee covers
 - (4) Flange and union covers
 - (5) End caps
 - (6) Beveled collars
 - (7) Valve covers
 - (8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available

2.08 TAPES:

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 1. Width: 3 inches
 2. Thickness: 11.5 mils

3. Adhesion: 90 ounces force/inch in width
 4. Elongation: 2 percent
 5. Tensile Strength: 40 lbf/inch in width
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Width: 3 inches
 2. Thickness: 6.5 mils
 3. Adhesion: 90 ounces force/inch in width
 4. Elongation: 2 percent
 5. Tensile Strength: 40 lbf/inch in width
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches
 2. Thickness: 3.7 mils
 3. Adhesion: 100 ounces force/inch in width
 4. Elongation: 5 percent
 5. Tensile Strength: 34 lbf/inch in width

2.09 SECUREMENTS:

A. Bands:

1. Stainless Steel: ASTM A240, Type 316; 0.015 inch thick, 3/4 inch wide with wing seal.

2.10 CORNER ANGLES:

- A. Aluminum Corner Angles: 0.040-inch-thick, minimum 1- by 1-inch aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- B. Stainless Steel Corner Angles: 0.024-inch-thick, minimum 1- by 1-inch stainless steel in accordance with ASTM A240, Type 316.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.03 GENERAL INSTALLATION REQUIREMENTS:

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.

- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- L. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices
2. Testing agency labels and stamps
3. Nameplates and data plates
4. Maintenance holes
5. Handholes
6. Cleanouts

3.04 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION:

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive, anchor pins, and speed washers.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints and 16 inches o.c. in both directions.
 - d. Do not over-compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches.
 8. Install insulation in removable segments on equipment access doors, maintenance holes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around maintenance holes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
 2. Fabricate boxes from aluminum or stainless steel, at least 0.050 inch thick.
 3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.05 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION:

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.06 FIELD-APPLIED JACKET INSTALLATION:

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

- 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
- 2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
- 3. Completely encapsulate insulation with coating, leaving no exposed insulation.

- B. Where FSK jackets are indicated, install as follows:

- 1. Draw jacket material smooth and tight.
- 2. Install lap or joint strips with same material as jacket.
- 3. Secure jacket to insulation with manufacturer's recommended adhesive.
- 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
- 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

- C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.07 FINISHES:

- A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 90 00.

- 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size

- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.08 EQUIPMENT INSULATION SCHEDULE, GENERAL:

- A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials is Contractor's option.

3.09 INDOOR EQUIPMENT INSULATION SCHEDULE:

- A. Insulate indoor and outdoor equipment that is not factory insulated.
- B. Chilled-glycol pump insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density
- C. Heating-hot-glycol pump insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density
- D. Chilled-glycol expansion/compression tank insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick
 - 2. Mineral-Fiber Board: 1 inch thick and 2-lb/cu. ft. nominal density
 - 3. Mineral-Fiber Pipe and Tank: 1 inch thick
- E. Heating-hot-water expansion/compression tank insulation shall be one of the following:
 - 1. Mineral-Fiber Board: 1 inch thick and 2-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Pipe and Tank: 1 inch thick
- F. Chilled-water air-separator insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick
 - 2. Mineral-Fiber Board: 1 inch thick and 2-lb/cu. ft. nominal density
 - 3. Mineral-Fiber Pipe and Tank: 1 inch thick

- G. Heating-hot-glycol air-separator insulation shall be one of the following:
 - 1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density
 - 2. Mineral-Fiber Pipe and Tank: 2 inches thick
- H. Piping system filter-housing insulation shall be the following:
 - 1. Mineral-Fiber Pipe and Tank: 2 inches thick
- 3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE:
 - A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - B. If more than one material is listed, selection from materials listed is Contractor's option.
 - C. Equipment, Concealed: None.
 - D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces of up to 72 Inches:
 - 1. Aluminum, Stucco Embossed: 0.024 inch thick
 - E. Equipment, Exposed, Larger than 48 Inches in Diameter or with Flat Surfaces Larger than 72 Inches:
 - 1. Aluminum, Smooth with 1-1/4-Inch-Deep Corrugations: 0.032 inch thick
- 3.11 CLOSEOUT ACTIVITIES:
 - A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide insulation for HVAC piping systems as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 1. 90.1-01: Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA co-sponsored; ANSI approved; Continuous Maintenance Standard).
- B. ASTM International (ASTM):
 - 1. B209: Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate Metric.
 - 2. C335: Standard Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - 3. C411: Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - 4. C449: Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - 5. C533: Calcium Silicate Block and Pipe Thermal Insulation.
 - 6. C547: Mineral Fiber Pipe Insulation.
 - 7. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - 8. C921: Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.

- B. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
 - C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
 - 1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 - 2. Sheet Form Insulation Materials: 12 inches square.
 - 3. Jacket Materials for Pipe: 12 inches long by NPS 2.
 - 4. Sheet Jacket Materials: 12 inches square.
 - 5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.
 - E. Qualification Data: For qualified Installer.
 - F. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
 - G. Field quality-control reports.
- 1.04 SUSTAINABLE DESIGN:
- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- C. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.08 DELIVERY, STORAGE, AND HANDLING:

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.09 COORDINATION:

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Sections 23 05 29 and 23 23 00.
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.10 SCHEDULING:

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS:

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Fiberglass: Heavy density resin bonded inorganic glass fibers.
 - 1. Comply with:
 - a. ASTM C547
 - b. ASTM C585
 - c. ASTM C1136
 - 2. Manufacturers:
 - a. Owens Corning – SSL II with ASJ.
 - b. Armacell
 - c. Rubatex
 - 3. Preformed Pipe Insulation: Type I, Grade A.

4. Preformed Pipe Insulation: Type IV, Grade B.
 5. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials, Type II for sheet materials.
1. Manufacturers:
 - a. Armacell
 - b. Kflex.
- 2.02 ADHESIVES:
- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 2. Wet Flash Point: Below 0 degrees F.
 3. Service Temperature Range: 40 to 200 degrees F.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers:
 - a. Foster
 - b. Johns Manville
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers:
 - a. Foster
 - b. Johns Manville

2.03 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: 0 to plus 180 deg F.
 - 3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
 - 4. Color: White
- C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: 0 to 180 deg F.
 - 3. Color: White
- D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
 - 3. Color: White
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
 - 2. 3. Service Temperature Range: 0 to plus 180 deg F.
 - 3. Color: White.

2.04 LAGGING ADHESIVES:

- A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
2. Service Temperature Range: 20 to plus 180 degrees F.
3. Color: White.

2.05 SEALANTS:

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 1. Permanently flexible, elastomeric sealant.
 2. Service Temperature Range: Minus 58 to plus 176 degrees F.
 3. Color: White or gray.
- C. FSK and Metal Jacket Flashing Sealants:
 1. Fire- and water-resistant, flexible, elastomeric sealant.
 2. Service Temperature Range: Minus 40 to plus 250 degrees F.
 3. Color: Aluminum.
- D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 1. Fire- and water-resistant, flexible, elastomeric sealant.
 2. Service Temperature Range: Minus 40 to plus 250 degrees F.
 3. Color: White.

2.06 FACTORY-APPLIED JACKETS:

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C1136, Type II.

2.07 FIELD-APPLIED JACKETS:

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 - 2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C1136, Type II.

2.08 FIELD-APPLIED CLOTHS:

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and provided a minimum of 8 oz./sq. yd.
- B. Metal Jacket:
 - 1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Finish and thickness are indicated in field-applied jacket schedules.
 - b. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and Kraft paper.
 - c. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and Kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - (1) Same material, finish, and thickness as jacket.
 - (2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - (3) Tee covers.
 - (4) Flange and union covers.
 - (5) End caps.
 - (6) Beveled collars.
 - (7) Valve covers.
 - (8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.09 TAPES:

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 6.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS:

- A. Bands: Stainless Steel: ASTM A240, Type 316; 0.015 inch thick, 3/4 inch wide with wing seal.

- B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.03 GENERAL INSTALLATION REQUIREMENTS:

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.

- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices
 - 2. Testing agency labels and stamps
 - 3. Nameplates and data plates

3.04 PENETRATIONS:

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.

- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
 - E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 07 84 00 for firestopping and fire-resistive joint sealers.
 - F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 00.
- 3.05 GENERAL PIPE INSULATION INSTALLATION:
- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.
 - B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.06 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION:

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.07 INSTALLATION OF MINERAL-FIBER INSULATION:

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Refrigerant Piping:

1. Install insulation in snug contact with pipe and in accordance with Manufacturer's recommendations.
 - a. Insulate flexible pipe connectors.
 - b. Insulate thermal expansion valves with insulating tape.
 - c. Insulate fittings with sheet insulation and as recommended by Manufacturer.
2. Slip insulation on tubing before tubing sections and fittings are assembled keeping slitting of insulation to a minimum.
3. Do not install insulation on lines through clamp assembly of pipe support. Butt insulation up against sides of clamp assembly.
4. Provide 6-inch-long, 20 ga galvanized steel sleeve around pipe insulation at each support. Extend insulation through pipe support clamps.
5. Stagger joints on layered insulation. Seal joints in insulation.
6. Install insulation exposed outside building so 'slit' joint seams are placed on bottom of pipe.
7. Paint exterior exposed insulation with two coats of specified exterior finish.
8. System Requirements:
 - a. Condensing Units - Install insulation on above-ground refrigerant suction piping and fittings, including thermal bulb, from thermal expansion valve.

- b. Split System Heat Pump Units - Install insulation on above-ground refrigerant liquid and suction piping and fittings.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.08 FIELD-APPLIED JACKET INSTALLATION:

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.09 FINISHES:

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 90 00 and Section 09 91 10.
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.

3.10 PIPING INSULATION SCHEDULE, GENERAL:

- A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Underground piping.
 - 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE:

- A. Condensate and Equipment Drain Water below 60 Degrees F:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 3/4 inch thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Chilled Water and Glycol:

1. NPS 2 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 3 to NPS 12: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

C. Heating-Hot -Water or Glycol Supply and Return:

1. NPS 2 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
2. NPS 3 and Larger: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE:

A. Chilled Water and Glycol:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 2 inches thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.13 REFRIGERANT FLEXIBLE FOAMED PIPE INSULATION

A. Flexible Foamed Pipe Insulation

1. Thickness -
 - a. 1/2 inch for one inch outside diameter and smaller pipe.
 - b. 3/4 inch for 1-1/8 through 2 inch outside diameter pipe.
 - c. One inch for 2-1/8 inches outside diameter and larger pipe (two layers of 1/2 inch.)
 - d. One inch sheet for fittings as recommended by Manufacturer.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE:

- A. If no factory jacket is provided install jacket over insulation material.

- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed: None
- D. Piping, Exposed in Non-Abuse Areas: ASJ
- E. Piping, Exposed in Abuse Areas: PVC
- F. Fitting Exposed in All Areas: PVC

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE:

- A. If no factory jacket is provided install jacket over insulation material.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed: Aluminum, Stucco Embossed: 0.024 inch thick.
- D. Piping, Exposed: Aluminum, Stucco Embossed with Z-Shaped Locking Seam: 0.024 inch thick.

3.16 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 09 23

AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide automatic temperature controls as indicated and in compliance with Contract Documents.
- B. This Section specifies the general requirements for monitoring and controlling HVAC equipment.
- C. The automatic temperature control system shall include integration with a Building Automation System (BAS).
 - 1. The BAS and control network shall be based on the open communication BACnet protocol.
- D. The HVAC system is to be complete with all necessary control components and connections to achieve the specified functions. Reference all control narratives for general outline of expected functionality.
- E. Furnish all materials, including all Human Machine Interface (HMI) hardware and software, operator input/output peripherals, standalone local control panels, automation sensors and controls, wiring, and interface systems.
- F. The control system is to be set up and adjusted to achieve energy efficient operation of the HVAC system. This includes sequencing, timing and re-adjustment, as required.
- G. This section is a performance specification clarified in certain sections to establish minimum standard of equipment, installation and level of control.
- H. Provide following electrical work as Work of this section, complying with requirements of Division 26:
 - 1. Control and power wiring between field installed controls, indicating devices, and unit control panels.
- I. Work by Others:
 - 1. Power supply wiring for HVAC Equipment and Automatic Temperature Control Panels.
- J. Related Requirements:
 - 1. Section 23 09 93 Automatic Control Sequences.

1.02 REFERENCES:

A. National Fire Protection Association (NFPA):

1. 70: National Electrical Code
2. NFPA 820 for Water Treatment Plants
3. ASHRAE 62.1

1.03 SUBMITTALS:

A. Provide submittals in accordance with Section 01 33 00 and the following:

1. Manufacturer's descriptive literature for each control device furnished indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and installation and startup instructions.
2. Control panel layouts including door mounted control and indication devices.
3. Interconnection schematics and communication network riser diagrams.
4. Wiring and piping diagrams.
5. One-line diagram from sensor and control devices to automatic temperature control panels including all components and cables.
6. Terminal cabinets, including termination listing.
7. Written description indicating sequence of operation.
8. Shop Drawings will be rejected if the written description is not included with the submission. Sequences should reference English descriptors and labels for each point described. Follow any established client cable and equipment tagging system.
9. All input/output points which are to include the following information associated with each point.
 - a. Sensing element type and location.
 - b. Details of associated field wiring schematics and schedules.
 - c. Software and programming details.
10. Detailed block diagrams of transmission trunk routing and configuration.
11. Valve and damper schedules indicating size, configuration, capacity and locations.

B. Submit shop drawings in accordance with Section 01 33 00.

1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and control devices.
 2. Label each control device with setting or adjustable range of control.
 3. Indicate required electrical wiring. Differentiate between portions of wiring factory-installed and portions field-installed.
 4. Provide details of faces of control panels including controls, instruments, and labeling.
 5. Provide one-line schematic for starters affected by control system showing interlocks between starters and control system and any other interlocks not necessarily provided as part of control system.
- 1.04 SUSTAINABLE DESIGN:
- A. Comply with the requirements specified in Section 01 81 13.01.
- 1.05 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.06 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
- 1.07 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.
- 1.08 FREEZE PROTECTION:
- A. All air supply handling units containing coils are to have a non-recycling, manual reset, electric line voltage freeze protection controller that stops the system upon sensing 40 degrees F.
 - B. The freeze protection controllers are to contain an additional set of dry contacts that closes on freeze detection for remote alarm indication at the SCADA.
 - C. The freeze protection contacts are to be connected on the common line after the HOA selector switch.
 - D. BAS to shut down all supply air handling units containing coils, upon sensing air off the coils at 40 degrees F.
 - E. Allow up to three (3) restarts, over short period before generating an alarm.

1.09 ALARMS – GENERAL:

- A. No alarm is to be triggered for a device until the device has been started and is in stable operation. Use software time delays to achieve this requirement.
- B. Generate an alarm on the SCADA if any equipment is not in the intended operating condition or if any analog input is not within the intended operating range.

1.10 MAINTENANCE

- A. Within 30 days after Substantial Completion, present to OWNER for consideration, preventive maintenance contract to cover service incidental to continued proper performance of system and devices during guarantee period.
- B. Maintenance of system components are not CONTRACTOR'S responsibility during and after guarantee period, unless contracted for by OWNER.
- C. Provide schedule of maintenance tasks necessary to keep CONTRACTOR guarantee in effect through guarantee period.
- D. Provide list of recommended preventive maintenance procedures including task frequency and tools required to perform tasks. Provide instructions for each task in O&M data.
- E. OWNER will keep records, schedules, and other reports documenting OWNER-performed prescribed maintenance procedures during guarantee period. CONTRACTOR not liable for defective systems, devices or components or repair, if OWNER-performed required preventive maintenance procedures not performed and documented.
- F. Warranty period: 24 months commencing at Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturer's equipment used as basis of design for Project is name indicated in Specification for particular type of equipment or application contained in Contract Documents subject to Owner acceptance. If no manufacturer listed, basis of design is industry standard indicated.
- B. Manufacturers:
 - 1. Automated Logic
 - 2. Johnson Controls, Inc.
 - 3. Alerton
 - 4. Or equal.

2.02 GENERAL:

- A. Provide automatic temperature control products and supporting system components of type, architecture, size, and capacities indicated, conforming to manufacturer's standard materials and components as published in product information; designed and constructed as recommended by manufacturer and required for application indicated.
- B. Provide a BACNet BAS system as a distributed control system. The system shall have local temperature control panels, a communications network, and a separate workstation computer with workstation software. The workstations and network controllers shall communicate to any outside network using TCP/IP protocol and addressing.
- C. Provide an operator programmable system to perform closed-loop, modulating control of building equipment. Connect all digital controllers through the communication network to share common data and report to workstation computer. Provide workstation BAS software capable of programming and monitoring the digital controllers. The control system shall be capable of downloading programs between the workstation and digital controllers.
- D. Apply digital controllers in a distributed control manner.
- E. Design, provide and install all conduit and wiring linking all elements of system, including future capability.
- F. All control units in the BAS are to be BACnet compliant with open protocol to allow future replacement of obsolete components or integration of another manufacturer's BACnet compliant components and any existing BAS system
- G. All control units in the BAS are to be BACnet compliant with open protocol to allow for integration with the SCADA system.
- H. Location of controllers to be approved by the Engineer prior to installation.
- I. Provide analog output and input devices utilizing a 0-10 VDC or 4-20 mA control signal. Verify input and output requirements from BAS to other vendor supplied equipment controls and configure accordingly.
- J. Provide field instrumentation and sensing devices analog or digital as applicable which measure temperature, humidity, pressure, flow, current, voltage, equipment states, etc., and which input signals to the SCU terminal strip that conform to the input requirements. All field devices will be of industrial grade.
- K. Provide output devices and actuators which convert the digital or analog output signal from the SCU to activate relays or open and close valves, dampers, etc.
- L. The end-to-end accuracy called for in Subsection 2.9 includes the combined effect of sensitivity, hysteresis, linearity and repeatability between the measured variable and the

input to the analog-to-digital converter in the SCU or between the SCU input to the digital-to-analog converter and the controlled variable for the full sensing range.

2.03 BAS SYSTEM INTERNET BASED ACCESSIBILITY

- A. The control system must be capable of Internet connectivity for remote accessibility by up to four (4) simultaneous users. Internet accessibility will be provided with same level of password protection (four levels) for internal accessibility. Internet based accessibility will provide full access to the BAS system including monitoring, diagnostic functions, setpoint adjustment, access to real time and archived trending data and reports.

2.04 STAND-ALONE CONTROLLERS:

A. Inputs:

1. Provide input function integral to the standalone controllers. Provide input type(s) as required by the systems design. For each type of input used on high-level controllers, provide at least one similar spare input point per controller.
2. Analog Inputs: Allowable input types are 100-ohm (or higher) platinum RTDs, 4-20 mA, and 2-10 VDC. Direct RTD inputs must have appropriate conversion curves stored in controller software or firmware. Analog to digital (A/D) conversion shall have 16-bit minimum resolution.
3. Digital Inputs: Digital inputs shall sense open/close, on/off, or other two state indications.

B. Outputs:

1. Provide output function integral to the standalone controller. Provide output type(s) as required by the systems design. For each type of output used on high-level controllers, provide at least one (1) similar spare output point per controller.
2. Analog Outputs: Provide controllers with 16-bit minimum output resolution. Output shall be 4-20 mA or 2-10 VDC.
3. Digital Outputs: Provide contacts rated at a minimum of 1 ampere at 24 V.

C. PID Control:

1. Provide controllers with proportional integral and derivative control capability.
2. The upper level digital controllers shall be capable of networking with other similar upper level controllers. Upper level controllers shall also be capable of communicating over a network between buildings.

D. Communications Ports:

1. Controller-to-Controller LAN Communications Ports: Controllers in the building BAS system shall be connected on a communications network. Controllers shall have controller to controller communication ports to both peer controllers (upper level controllers) and terminal controllers (lower level controllers). Network may consist of more than one level of local area network and one level may have multiple drops. Communications network shall permit sharing information between controllers, allowing execution of dynamic control strategies, and coordinated response to alarm conditions. Minimum speed for all LAN's is 100 Mbps.
2. Interface Ports: Provide a RS-232 or RS-485 communications ports for each digital controller that allows direct connection of a computer or handheld terminal and through which the controller may be fully accessed. Controller access shall not be limited to access through another controller. Interface communication ports shall be in addition to the communications port(s) supporting controller to controller communications. Communication rate is 9600 Baud minimum. Every controller on the highest-level LAN shall have a communications port supporting direct connection of a computer; a handheld terminal port is not sufficient. By connecting a computer to this port, every controller in the direct digital control system shall be accessible and programmable. The following operations shall be available: downloading and uploading control programs, modifying programs and program database, and retrieving or accepting trend reports, status reports, messages, and alarms.
3. Remote Workstation Interface Port: Provide one (1) additional direct connect computer port in each BAS system for permanent connection of a remote operator's work station, unless the workstation is a node on the LAN. All operations possible by directly connecting a computer to a controller at the highest-level LAN shall be available through this port.

2.05 ETHERNET NIC:

- A. Provide one (1) Ethernet NIC per BAS system to communicate between the digital control system and the computer workstation. Minimum Ethernet transmission rate is 100 Gigahertz.
- B. The BACnet communication network system will be redundant design such that a failure of a single communication link or node will not impact the ability of the system/sub-system to communicate with other nodes.

2.06 TEMPERATURE CONTROL CABINETS:

- A. Each indoor digital controller cabinet shall protect the controller from dust and rated NEMA 1, unless specified otherwise. Refer to Electrical drawings for area classifications and categories. Each outdoor digital controller cabinet shall protect the controller from all outside conditions and rated NEMA 4. Cabinets for high level controllers shall be hinged door, lockable, and have offset removable metal back plate.

- B. Make all wiring connections in the shop from the equipment mounted on the panel to numbered terminal blocks conveniently located in the panel, including the power supply for all instruments.
- C. Identify all wiring by means of stamped markings on heat shrinkable tubing. Install all wiring neatly and laced or bunched into cable form using plastic wire clips, where practical, contained in plastic wiring channels with covers. Maximum twenty-five (25) conductors to each wire bundle.
- D. Install "Hand-Off-Auto" selector switches such that safety controls and electrical over current protection are not overridden when selector switch is in the "Hand" position.

2.07 MAIN POWER SWITCH:

- A. Each controller on the highest-level LAN or each control cabinet shall have a main external power switch for isolation of the controller from AC power. The switch shall be in the BAS cabinet.

2.08 TERMINAL CONTROL UNITS:

- A. The same company as the digital controllers shall manufacture terminal control units.
- B. Terminal control units shall automatically start-up on return of power after a failure, and previous operating parameters shall exist or shall be automatically downloaded from a parent controller on a higher-level LAN.
- C. Terminal control units do not require an internal clock if they get time information from a parent controller.

2.09 WIRE

- A. Control wiring for digital functions shall be 18 AWG minimum with 300 V insulation control wiring for analog functions shall be 18 AWG minimum with 300 V insulation, twisted and shielded, 2 or 3 wire to match analog function hardware.
- B. Sensor wiring shall be 18 AWG minimum twisted and shielded, 2 or 3 wire to match analogue function hardware or 16 AWG as required by code.
- C. Transformer current wiring shall be 16 AWG minimum.

2.10 CONDUITS AND CABLES

- A. All wiring shall be in conduit or trays. Conform to Division 26 Sections for conduit and tray requirements.
- B. Seal conduit where such conduit leaves heated areas and enters unheated area.
- C. Run low level signal lines in separate conduit from high level signal and power transmission lines.

- D. Identify each cable and wire at every termination point.
- E. Where applicable, mount field interface equipment (i.e. relays, transducers, etc.) in local device cabinets adjacent to field interface panels.
- F. Separate conduits shall be provided for pneumatic tubing and electrical wiring runs.
- G. Color code all conductors and conduits by permanently applied color bands on maximum 30-foot intervals. Color code shall follow base building schedule.

2.11 RELATED ACCESSORIES

- A. Provide and install all necessary transformers, transducers, interposing relays, interface devices, and contractors to perform control functions required.
- B. It is the responsibility of the Contractor to identify, at the time of Bid submission, all additional items not specified that are required to meet the operational intent specified.
- C. Items required but not identified at the time of Bid acceptance shall be the Contractor's responsibility.

2.12 CONTROL DAMPERS:

- A. General:
 - 1. See Section 23 09 23.12 for control damper requirements.
- B. Instrumentation and Controls:
 - 1. The dampers shall have the option of being controlled locally or remotely via the BAS system.
- C. Shop Assembly:
 - 1. The dampers shall be fully assembled to the maximum extent possible.

2.13 CONTROL DAMPER OPERATORS:

- A. General:
 - 1. See Section 23 09 23.12 for control damper actuator requirements.
 - 2. Drawings indicate only one damper motor for each motorized damper.
 - 3. Select actual quantity of motors required to operate each damper in accordance with the size of damper provided.
 - 4. Coordinate exact quantity of damper motors with electrical Work to ensure that necessary wiring and conduit is provided for installation.

5. Provide operators for motorized dampers and motorized louvers for all cases where an operator is not supplied as part of a unit.

2.14 AUTOMATIC CONTROL VALVES:

A. General:

1. See Section 23 09 23.11 for automatic control valve requirements.

2.15 VALVE ACTUATORS:

A. General:

1. See Section 23 09 23.11 for valve actuator requirements.

2.16 ELECTRIC THERMOSTATS:

A. Office Area Room Thermostat:

1. Modulating electric type, remote and average sensor capable.
2. Temperature Scale: Furnish 35 to 95 degrees F dial.
3. Temperature setpoint adjustment, temperature display, timed unoccupied override function.
4. Insulating back, where exterior wall mounting is indicated in the Contract Documents.

B. Non-Office Area Room Thermostat:

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 35 to 95 degrees F dial.
3. Temperature setpoint adjustment, temperature display.
4. Adjustable sensitivity.
5. Insulating back where exterior wall mounting is indicated in the Contract Documents.
6. Enclosure and sensing element to match area classification and moisture/corrosion category.

2.17 ELECTRONIC SENSORS:

A. Temperature:

1. General Requirements:
 - a. Sensors and transmitters shall be provided, as outlined in the control schematics, input/output summary and sequence of operations.
 - b. Temperature sensor shall be resistance type and shall be two-wire 1,000-ohm platinum RTD.
2. Room Temperature:
 - a. Constructed for either surface or wall box mounting.
3. Room Temperature Sensors with Integral Display
 - a. Constructed for either surface or wall box mounting.
 - b. Integral LCD display and four button keypad with the following capabilities:
 - (1) Display room and outside air temperatures
 - (2) Display and adjust room comfort set point
 - (3) Display and adjust fan operation status
 - (4) Timed override request pushbutton with LED status for activation of after-hours operation
 - (5) Display controller mode
 - (6) Password selectable adjustment of set point and override modes
4. Duct Temperature:
 - a. Accuracy: +/-1 degree F
 - b. Range:
 - (1) Heating: 40 to 140 degrees F
 - (2) Cooling: 30 to 100 degrees F
 - c. Element:
 - (1) Rigid insertion, 12-inch length, through sealed opening in center of duct.
 - (2) Averaging, for ducts or plenums with any dimension greater than 36 inches. Sealed opening in duct. Sensing element incorporated in copper

capillary a minimum of 20 feet long, serpentine across full area of airflow.

5. Water Temperature:

- a. Accuracy: +/-1 degrees F
- b. Range: 30 to 100 degrees F for Chilled water supply/return; 50 to 250 degrees F for heating glycol supply and return
- c. Element: Removable insertion into pipe thermowell
- d. Cover: NEMA 250 Type, suitable for area classification; in accordance with NFPA 70

6. Outdoor Temperature:

- a. Accuracy: +/-1 degrees F
- b. Range: -40 to 140 degrees F
- c. Cover: Weathertight, with sealed conduit connection and sun shield

B. Pressure (PS):

1. Air Pressure:

- a. Accuracy: 5 percent of range
- b. Range: 150 percent of measured variable
- c. Mount non-vibrating
- d. Cover: NEMA 250 Type, suitable for area classification; in accordance with NFPA 70

2. Water Pressure:

- a. Dwyer Instruments Inc.; No. 630 Series, 0 to 20 psi
- b. Transicoil Inc. (Robinson Halpern); No. 151 Series

C. Differential Pressure:

1. General:

- a. Temperature compensated.

- b. Vary output voltage with change in differential pressure. Voltage shall vary linearly from 0 to 10V DC according to differential pressure between high and low pressure ports.
 - c. Sensing range shall be suitable for application with linearity of 1.5 percent of full scale and offset of less than 1 percent of full scale.
 - d. Capable of withstanding up to 150 percent of rated pressure without damage.
 - e. Compatible with 14V to 30V DC supply voltage range.
- 2. Duct Air Static Differential Pressure (Flow Measurement):
 - a. Ultra-low differential pressure and flow transmitter
 - b. 0.5 percent of natural span accuracy
 - c. 4-20 mA output.
 - d. Pressure range to suit application
 - e. Integral 3-way zeroing valve
 - f. Built-in square root function
 - g. NEMA 12 enclosure
 - h. Veltron DPT 2500 transmitter with NEMA 12 enclosure
 - i. Sensicon A3 controller/display with NEMA 12 enclosure
- 3. Space Air Static Differential Pressure: MAMAC Systems Inc. or Setra transmitter
- 4. Water Differential Pressure:
 - a. Dwyer Instruments Inc.; No. 630 Series, 0 to 20 PSI range
 - b. Rosemount Controls Inc.; No. 1151-DP Series
 - c. Include three-valve manifold connection
- D. Position Indicator:
 - 1. 0 to 100 percent open, for damper, inlet vane, or similar
 - 2. Potentiometer, 0 to 2,000 ohm equals 0 to 100 percent
- E. Relative Humidity (RH):

1. Room Relative Humidity
2. Accuracy: +/-2 percent
3. Range: 10 to 95 percent
4. Solid state

F. Current Sensors (CS):

1. Fixed Setpoint, Digital Output Current Switch:
 - a. Manufacturer:
 - (1) Veris Industries Inc.; Hawkeye 600/800
 - b. Application: Monitoring status of direct drive equipment
 - c. Current-operated solid-state relay
 - d. Split core design
 - e. Trip Setpoint: Fixed
 - f. Output: Digital switch
 - g. Sensor Power: Induced from line
2. Adjustable Setpoint, Analog Output Current Sensor:
 - a. Manufacturer:
 - (1) Veris Industries Inc.; Hawkeye H721LC/721HC
 - b. Application: Monitoring status of belt drive equipment
 - c. Current-operated solid state transducer
 - d. Split core design
 - e. Output: Analog
 - f. Sensor Power: Induced from line
3. Adjustable Setpoint, Digital Output, VFD Current Switch:
 - a. Manufacturer:
 - (1) Veris Industries Inc.; Hawkeye 904

- b. Application: Monitoring status of belt-drive or direct-drive equipment controlled by a VFD
- c. Microprocessor-based current-operated solid state relay
- d. Automatic compensation for VFD frequency and current changes
- e. Split core design
- f. Trip Setpoint: Self-calibrating
- g. Output: Digital switch, with normal and alarm status LED
- h. Sensor Power: Induced from line

2.18 AIR MEASURING STATION

- A. The air measuring station shall consist of multiple aluminum airflow measuring elements containing multiple total and static pressure sensing ports placed along the leading edge of the cylinder. The static pressure chamber shall incorporate dual offset static taps on opposing sides of the averaging chamber capable of accommodating flow angle variations of plus or minus 20 degrees in the approaching airstream. The probes shall be manifolded together in a 0.06 inch type 316 stainless steel duct section with 90 degree undrilled flanges, fabricated to the duct size, and shall contain multiple interconnected airflow traverse elements.
- B. Where primary flow elements are located outside of the Manufacturer's published installation guidelines the manufacturer shall be consulted, and approve of any special configurations, such as air equalizers and/or additional and strategically placed measuring points, as may be required.
- C. The airflow traverse elements shall be capable of producing steady, non-pulsating signals of true total and static pressure. Signal amplifying sensors requiring flow correction (K factors) for field calibration are not acceptable.
- D. Accuracy: Plus or minus 2 percent
- E. Operating Velocity Range: 100 to 1000 feet per minute
- F. Operating Temperature Range: minus 20 to 104 degrees F
- G. Air Pressure Drop: < 0.18 inches WG Pa at 4000 feet per second
- H. Generated Noise Level: < NC40
- I. Acceptable Manufacturers:
 - 1. Greenheck

2. Ruskin
3. PCI
4. Ebtron
5. Or equal.

2.19 HIGH TEMPERATURE DETECTORS:

- A. The high temperature switch shall be of the automatic reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC. An auxiliary contact shall be provided for remote alarm (EMS) monitoring of a high temperature condition.
- B. The sensing element shall be bi-metal type.
- C. Sensing element shall react to the warmest section of the multi section element.
- D. Thermostat element shall be a probe type.
- E. For large duct areas where the sensing element does not provide full coverage of the air stream, additional thermostats shall be provided as required to provide full protection of the air stream.
- F. Provide means of providing a time delay on the high temperature cut out where required and indicated on the Drawings.

2.20 LOW TEMPERATURE DETECTORS:

- A. The low temperature switch shall be of the automatic reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC. An auxiliary contact shall be provided for remote alarm (EMS) monitoring of a low temperature condition.
- B. The sensing element shall be a minimum of 20 feet in length and shall react to the coldest 18-inch section.
- C. Element shall be of sufficient length to allow a serpentine distribution across the duct cross section and provide an accurate indication of the air flow temperature, especially in the case where a mixed air temperature is being measured.
- D. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
- E. Provide means of providing a time delay on the low temperature cut out where required and indicated on the Drawings.

2.21 BAS SOFTWARE:

- A. Provide, in the digital controllers, software to execute the sequence of control. Provide one (1) registered copy of all software used to program control sequences in all direct digital controllers and LAN controllers on the computer workstation. Provide any access keys which restrict programming language software functions or the ability to compile or prepare programming for download to controllers. Provide final copy of each program used in the system in both compiled and editable formats. Where specially programmed factory configured smart controllers are used in the system, provide minimum factory programming tools and specialized controller programs ready for download to replacement controllers. At minimum, controllers must be capable of performing programming functions outlined in the following "Parameter Modification" section.
- B. Provide software to modify control parameters. Parameter modification for all controllers (high level and low-level application specific) is through the main workstation computer and with laptop computer or keypad terminal directly at each controller. Modifications are to be accomplished without having to make changes directly in line-by-line programming. When the control program is of the line-by-line type, database parameters in the following list that take real number values require assignment of variable names so parameters can be changed without modifying programming. Alternatively, block programming languages shall provide for modification of these database parameters in fill-in-the-blank screens. Parameters of like type, including those in different high level and low-level controllers, may be grouped together for a single, global change. For example, an operator may group all second-floor space temperature setpoints into a group and raise the setpoint by two degrees with a single command. The following parameters shall be modifiable in this way:
 - 1. Setpoints.
 - 2. Dead band limits and spans.
 - 3. Reset schedules.
 - 4. Switch over points.
 - 5. PID gains and time between control output changes.
 - 6. Time.
 - 7. Timed local override time.
 - 8. Occupancy schedules.
 - 9. Holidays.
 - 10. Alarm points, alarm limits, and alarm messages.
 - 11. Point definition database.

12. Point enable, disable, and override.
 13. Trend points, trend intervals, trend reports.
 14. Analog input default values.
 15. Passwords.
 16. Communications parameters including network and telephone communications setups.
- C. Differential:
1. Where setpoint is in response to some analog input such as temperature, pressure, or humidity, include a setpoint differential to prevent short cycling of control devices.
- D. Motor and Flow Status Delay:
- E. Provide an adjustable delay between when a motor is commanded on or off and when the control program looks to the motor or flow status input for confirmation of successful command execution.
- F. Run Time Accumulation:
1. Provide resettable run time accumulation for each controlled digital output.
- G. Time Programs:
1. Provide programs to automatically adjust for leap years, daylight savings time, and operator time adjustments.
- H. Scheduling:
1. Individual controlled equipment shall be schedulable with schedule based on time of day, day of week, and day of year. Equipment may be associated into groups. Each group may be associated with a different schedule. Changing the schedule of a group shall change the schedule of all equipment in the group. Groups may be modified, created, and deleted by the operator.
 2. Provide capability to view and modify schedules in a seven-day week format. When control program does not automatically compute holidays, provide capability to enter holiday schedules one (1) full year at a time.
- I. Point Override:
1. I/O and virtual points shall accept software overrides to any possible value.
- J. Alarming:

1. I/O points and software points shall be alarmable. Alarms may be enabled and disabled for every point. Alarm limits shall be adjustable on analog points. Controllers connected to an external communications device such as a printer, terminal, or computer, shall download alarm and alarm message when alarm occurs. Otherwise alarms will be stored and automatically downloaded when a communications link occurs. In addition to those described in Schedule 18 C11.4, the following conditions shall generate alarms:
 - a. An analog input takes a value indicating sensor failure.
 - b. A module is not communicating on the LAN.
 - c. A power outage occurs.
 - d. Activation of any emergency eyewash or emergency shower.

K. Messages:

1. Messages shall consist of the device tag number, the device/associated equipment description and fault, and be assigned to alarm or status conditions. Messages shall be displayed on the workstation and be capable of being printed when these conditions occur.

L. Trending:

1. BAS system shall have the capability to trend all I/O and virtual points. Points may be associated into groups. A trend report may be set up for each group. The period between logging consecutive trend values shall range from fifteen seconds to sixty (60) minutes at a minimum. The minimum number of consecutive trend values stored at one time shall be 6000 per variable. Trend data shall be uploaded to workstation computer automatically for archiving and processing prior to controller storage being exceeded, maximum once per day. Trend data shall be available on a real time or archived basis; trend data shall appear numerically and graphically on a connected computer's screen as the data is processed from the BAS. Workstation software will process the data into user defined reports. The system must be able to show single or multiple values in multiple ranges on a single graph, including the ability to mix analog and digital signals. The time scale must be user definable. The line types must be able to be displayed in a variety of formats including column, line, symbol, scatter or area. The user must be able to zoom and scroll on the trend. The trend should be capable of displaying a user selected point value. Database for storing of archived data and reports shall be in ASCII format compatible for export to common database manipulation programs (e.g. Microsoft Access, Microsoft Excel). Archived data and reports shall be kept and be retrievable for a minimum of two (2) years.

M. Status Display:

1. Current status of I/O and virtual points shall be displayed on command. Points shall be associated into functional groups, such as all the I/O and virtual points associated with control of a make-up air unit, and displayed as a group, so the status of a single mechanical system can be readily checked. A group shall be selectable from a menu of groups having meaningful names.

N. Diagnostics:

1. Each controller shall perform self-diagnostic routines and provide messages to an operator when errors are detected. The BAS shall be capable of recognizing a non-responsive module on a LAN. The remaining, responsive modules on a LAN shall not operate in a degraded mode.

O. Power Loss:

1. During a power outage, each controller shall assume a disabled status and outputs shall go to a user definable state. Upon restoration of power, the BAS shall perform an orderly restart, with sequencing of outputs.

P. Program Transfer:

1. Provide software for download of control programs and database from a computer to controllers and upload of same to a computer from controllers. Every digital controller in the BAS shall be capable of being downloaded and uploaded to through a single controller on the highest-level LAN.

Q. System Back-up and Restoration:

1. The entire control system shall be capable of being backed-up or restored to or from a single back-up storage media.

R. Password Protection:

1. Provide at least four (4) levels of password protection to the BAS permitting different levels of access to the system. The lowest level allows monitoring only. The highest level allows full control of all functions, including setting new passwords.

S. Operator Workstation:

1. BAS System provider will a method of human interface with the BAS via Internet or Windows 10 laptop device.

PART 3 - EXECUTION

3.01 GENERAL – INSTALLATION OF FIELD COMPONENTS AND INSTRUMENTS:

- A. The control drawings and/or control sequences indicate only the principal items of equipment controlling the systems. Supplement each control system with all devices (e.g. relays) gauges and auxiliaries required to enable each system to perform as specified and to permit proper operation and supervision of same.
- B. Upon completion of the Work, all control devices shall be calibrated, tested and verified, as required, to place the system in complete and satisfactory operating condition.
- C. Notify the Consultant in writing of any conflict between these Specifications and the manufacturer's instructions.
- D. All equipment installed shall be mechanically stable and, as necessary, fixed to floor or wall. Anti-vibration mounts to be provided, where required, for the proper isolation of equipment.
- E. Install equipment so as to allow for ease of maintenance access such that it does not interfere in any way with access to adjacent equipment and personnel traffic in the surrounding space.
- F. Install equipment in locations having suitable ambient conditions for its specified functioning, allowing for adequate ventilation and the prevention of condensation traps.
- G. Outdoor installation is to be weatherproof construction in NEMA 4X enclosures.
- H. Ensure that all holes drilled in ductwork and HVAC equipment housings are properly sealed to eliminate leakage and to maintain the pressure rating of the equipment in question.
- I. Confirm Operator Workstation location with Engineer prior to installation.
- J. Install damper motors on outside of ducts. Do not locate in air stream.
- K. Wire "hand/off/auto" selector switches such that automatic operating controls and not safety controls and electrical over current protection shall be overridden when switch is in the "hand" position.
- L. Coordinate and confirm all controller set points with the balancing Contractor to verify all minimum and maximum air volumes on VSD controlled fans, air handlers and make-up air units.
- M. Provide copies of proposed control screens to Engineer for review prior to implementation.

3.02 TEMPERATURE SENSORS AND THERMOWELLS:

- A. Provide mixed air temperature sensors of a sufficient length to give an accurate temperature indication for the cross section of mixing plenum or duct involved. Install sensors in a serpentine arrangement about the plane of stratification (horizontal or vertical) so that an equal length of the sensing element covers an equal area of the mixing plenum, and an accurate measurement of the mixed air temperature is achieved.
- B. Unless otherwise indicated in the Contract Documents, mount space sensors 60 inches above the finished floor level. Confirm exact location of all thermostats prior to roughing-in.
- C. In process/service areas, utility rooms and other areas where the thermostat might be subject to damage, provide a metal cage or cast aluminum thermostat guard.
- D. Drill holes, weld thread-o-lets and mount thermowells in piping after isolating and draining the section to be worked on. Notify the Consultant/Regions before doing so. Install sensors in thermowells with dust-tight connection heads. Ensure sensor element is immersed in heat transfer compound and firmly seated against tip of well. Element shall extend at least two thirds of the pipe diameter into the pipe. Install sensor in region of piping where well-mixed conditions exist (e.g., at a pipe bend) wherever possible. Where pipe diameter is less than the length of the sensing element, mount sensor at piping elbow. Use stainless steel thermowells with extensions, where required, to accommodate thickness of insulation. Replace and repair insulation and pipe jacketing to return to original condition.

3.03 INSTALLATION OF CONTROL SYSTEM COMPONENTS:

- A. Provide control wiring of any voltage including installation required to interconnect control components located on air handling units and power wiring between lighting panel circuits provided under Division 26 and field-mounted controllers. Refer to electrical wiring diagrams for details regarding interconnection wiring requirements with control components.
- B. Sensor and control device wiring are to be as recommended by the control system manufacturer.
- C. Provide all contacts and interfaces required for pickup of alarm and status points for systems and equipment as indicated on the Drawings.

3.04 INSTALLATION OF THERMOSTATS:

- A. Unless otherwise specified in the Contract Documents, provide all required line voltage thermostats, including those for unit heaters and fan coils.
- B. Unless otherwise indicated in the Contract Documents, mount room thermostats 60 inches above the finished floor level. Confirm exact location of all thermostats prior to roughing-in.

- C. Provide stand-off mounting and an insulated sub-base for thermostats on outside walls.
- 3.05 INSTALLATION OF HIGH AND LOW TEMPERATURE DETECTORS, AND ACCESSORIES:
- A. Element shall be mounted across duct to in a serpentine arrangement about the plane of stratification (horizontal or vertical) so that an equal length of the sensing element covers an equal area of the mixing plenum, and an accurate measurement of temperature is achieved.
- 3.06 INSTALLATION OF CONTROL COMPONENT PANELS:
- A. Provide at locations indicated on the Drawings or implied by the Drawings and Control Specifications. Locate panels to provide a convenient operator interface with control system.
 - B. Surface wall mount or secure in place between free-standing galvanized structural steel members.
 - C. Confirm exact cabinet locations prior to roughing-in.
- 3.07 ACCEPTANCE TESTING:
- A. A final operational acceptance test of seven (7) consecutive days shall be conducted on the complete and total installed and operational control system to demonstrate that it is functioning properly in accordance with the Specifications.
 - 1. Acceptance testing will require the BAS integrated systems to be functional
 - B. The correct operation of all monitored and controlled points shall be demonstrated as well as the operation and capabilities of all sequences, reports, specialized control programs and algorithms, diagnostics and all other software.
 - C. In the event of the failure of function, during the test, of any of the hardware components or software application or routines, the test will recommence and run until seven (7) failure-free test days have occurred.
 - D. After successful completion of the acceptance test, the Engineer will issue written acceptance of the control system.
 - E. Prior to acceptance of the Work, submit hard copy and electronic copy on disk of final database listings.
- 3.08 TRAINING:
- A. Construction Contractor to provide three (3) weeks written notice to the Engineer prior to commencing formal training sessions.

- B. Formal training sessions shall commence only after "As-Constructed" Drawings have been completed, reviewed and approved by the Engineer.
- C. Training activities to include 3 consecutive days of on-site training to be arranged with the owner's facility management department at least one-month prior.

3.09 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 09 23.11

CONTROL VALVES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide control valves and actuators as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. ANSI FCI:

- 1. 70-2: Control Valve Seat Leakage

- B. American Society of Mechanical Engineers (ASME):

- 1. Boiler and Pressure Vessel Code
 - 2. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
 - 3. B61.1: Standard Specification for Steam or Valve Bronze Castings

- C. ASTM International (ASTM):

- 1. A126: Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - 2. A216: Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
 - 3. A536: Standard Specification for Ductile Iron Castings
 - 4. B61: Standards Specification for Steam or Valve Bronze Castings
 - 5. B62: Standard Specification for Composition Bronze or Ounce Metal Castings
 - 6. B584: Standard Specification for Copper Alloy Sand Castings for General Applications

- D. International Society of Automation (ISA):

- 1. 75.01.01: Industrial-Process Control Valves – Part 2-1: Flow Capacity – Sizing Equations for Fluid Flow Under Installed Conditions

2. 75.08.01: Face-to-Face Dimensions for Integral Flanged Globe-Style Control Valve Bodies (Classes 126, 150, 250, 300 and 600)

3. 75.11.01: Inherent Flow Characteristics and Rangeability of Control Valves

E. Manufacturers' Standardization Society (MSS):

1. SP-67: Butterfly Valves

2. SP-68: High Pressure Butterfly Valves with Offset Design

3. Sp-110: Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

1.03 DEFINITIONS:

A. Cv: Design valve coefficient

B. DDC: Direct-digital control

C. NBR: Nitrile butadiene rubber

D. PTFE: Polytetrafluoroethylene

1.04 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.

4. Installation, operation, and maintenance instructions, including factors affecting performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- D. Delegated-Design Submittal:
1. Schedule and design calculations for control valves and actuators, including the following:
 - a. Flow at project design and minimum flow conditions.
 - b. Pressure differential drop across valve at project design flow condition.
 - c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
- E. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.
- 1.05 SUSTAINABLE DESIGN:
- A. Comply with the requirements specified in Section 01 81 13.01.
- 1.06 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.07 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
- 1.08 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.
- E. Environmental Conditions:
 - 1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
 - a. Hazardous Locations: Explosion-proof rating for condition.
- F. Selection Criteria:
 - 1. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
 - 2. Valve pattern, three-way or straight through, shall be as indicated on drawings or control schematics.
 - 3. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
 - 4. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
 - 5. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.
 - 6. Selection shall consider viscosity, flashing, and cavitation corrections.
 - 7. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.

8. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.
9. Two-position control valves shall be line size unless otherwise indicated.
10. In water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.
11. Globe-style motorized control valves are to be used for all modulating flow applications.

2.02 BALL-STYLE CONTROL VALVES:

A. Ball Valves with Single Port and Characterized Disk:

1. Manufacturers:
 - a. Jenkins Valves
 - b. Toyo
 - c. Crane
 - d. Kitz Corporation
 - e. Milwaukee Valve Company
 - f. WATTS
 - g. MAS
 - h. Belimo
 - i. Or equal
2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 degrees F.
6. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze.

9. Stem and Stem Extension:
 - a. Material to match ball.
 - b. Blowout-proof design.
 - c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.
10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristic: Equal percentage.

2.03 BUTTERFLY-STYLE CONTROL VALVES:

A. Commercial-Grade, Two-Way Butterfly Valves:

1. Manufacturers:
 - a. Keystone
 - b. Kitz Corporation
 - c. Apollo Flow Controls
 - d. NIBCO, Inc.
 - e. Toyo
 - f. Tyco Grinnell
 - g. MAS
 - h. Or equal
2. Performance:
 - a. Bi-directional bubble tight shutoff at 250 psig.
 - b. Comply with MSS SP-67 or MSS SP-68.
 - c. Rotation: Zero to 90 degrees.
 - d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216 WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:
 - a. Manufacturer's name, model number, and serial number
 - b. Body size
 - c. Body and trim materials
 - d. Flow arrow

2.04 GLOBE-STYLE CONTROL VALVES:

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body and trim size.
 - c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:

1. Manufacturers:
 - a. Johnson Controls
 - b. Fisher
 - c. Siemens
 - d. Belimo
 - e. Or equal
2. Globe Style: Single port.
3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
4. End Connections: Threaded.
5. Bonnet: Screwed.
6. Packing: PTFE V-ring.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Stainless steel.
9. Process Temperature Range: 35 to 248 degrees F.
10. Ambient Operating Temperature: 35 to 150 degrees F.
11. Leakage: FCI 70-2, Class IV.
12. Rangeability: 25 to 1.
13. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 and Smaller:

1. Manufacturers:
 - a. Johnson Controls
 - b. Fisher
 - c. Siemens
 - d. Belimo

- e. Or equal
 - 2. Globe Style: Mix flow pattern.
 - 3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
 - 4. End Connections: Threaded.
 - 5. Bonnet: Screwed.
 - 6. Packing: PTFE V-ring.
 - 7. Plug: Top guided.
 - 8. Plug, Seat, and Stem: Stainless steel.
 - 9. Process Temperature Range: 35 to 248 degrees F.
 - 10. Ambient Operating Temperature: 35 to 150 degrees F.
 - 11. Leakage: FCI 70-2, Class IV.
 - 12. Rangeability: 25 to 1.
 - 13. Linear flow characteristic.
- D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:
- 1. Manufacturers:
 - a. Johnson Controls
 - b. Fisher
 - c. Siemens
 - d. Belimo
 - e. Or equal
 - 2. Globe Style: Single port.
 - 3. Body: Cast iron complying with ASME B61.1, Class 125.
 - 4. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
 - 5. Bonnet: Bolted.
 - 6. Packing: PTFE cone-ring.

7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 degrees F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

E. Three-Way Globe Valves NPS 2-1/2 to NPS 6:

1. Manufacturers:
 - a. Johnson Controls
 - b. Fisher
 - c. Siemens
 - d. Belimo
 - e. Or equal
2. Globe Style: Mix flow pattern.
3. Body: Cast iron complying with ASME B61.1, Class 125.
4. End Connections: Flanged suitable for mating to ASME B16.5, Class 150 flanges.
5. Bonnet: Bolted.
6. Packing: PTFE cone-ring.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 degrees F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

2.05 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS:

- A. Manufacturers:
 - 1. Belimo
 - 2. Johnson Controls
 - 3. Siemens
 - 4. Or equal
- B. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.
- C. Position indicator and graduated scale on each actuator.
- D. Type: Motor operated, with or without gears, electric and electronic.
- E. Voltage: Voltage selection delegated to professional designing control system.
- F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
- G. Function properly within a range of 85 to 120 percent of nameplate voltage.
- H. Construction:
 - 1. For Actuators Less than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
 - 3. For Actuators Larger than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- I. Field Adjustment:
 - 1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
 - 2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
- J. Two-Position Actuators: Single direction, spring return or reversing type.
- K. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
 - a. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- and 4- to 20-mA signals.
 - b. Programmable Multi-Function:
 - (1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
 - (2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.

L. Position Feedback:

1. Equip two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

N. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.

2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.
- P. Temperature and Humidity:
1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 degrees F.
 2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.
- Q. Enclosure:
1. Suitable for ambient conditions encountered by application.
 2. NEMA 250, Type 2 for indoor and protected applications.
 3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
 4. Provide actuator enclosure with heater and control where required by application.
- R. Stroke Time:
1. Operate valve from fully closed to fully open within 60 seconds.
 2. Operate valve from fully open to fully closed within 60 seconds.
 3. Move valve to failed position within 25 seconds.
 4. Select operating speed to be compatible with equipment and system operation.
- S. Sound:
1. Spring Return: 62 dBA
 2. Non-Spring Return: 50 dBA

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONTROL VALVE APPLICATIONS:

- A. Control Valves:
 - 1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

3.03 INSTALLATION, GENERAL:

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway.
- D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.
- F. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Laboratory exhaust airstreams.
 - b. Process exhaust airstreams.
3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRIC POWER:

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install raceways. Comply with requirements in Section 26 05 33.

3.05 CONTROL VALVES:

- A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
- B. Install flanges or unions to allow drop-in and -out valve installation.
- C. Where noted below, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.
 1. Bypass at all ERV, Air handler and Make-up Air Handler heating and cooling coils.
- D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 2.
- E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.
- F. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.06 CONNECTIONS:

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 26 05 26.

3.07 IDENTIFICATION:

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53.

- B. Install engraved phenolic nameplate with valve identification on valve.

3.08 CLEANING:

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

3.09 CHECKOUT PROCEDURES:

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING:

- A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- C. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

3.11 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 09 23.12

CONTROL DAMPERS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide control dampers and actuators for DDC systems as indicated and in compliance with Contract Documents.
 - 1. Rectangular control dampers
 - 2. Round control dampers
 - 3. General control-damper actuator requirements
 - 4. Electric and electronic actuators
- B. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).
- C. Select actual quantity of motors required to operate each damper in accordance with the size of damper provided.
- D. Coordinate exact quantity of damper motors with electrical Work to ensure that necessary wiring and conduit is provided for installation.

1.02 REFERENCES:

- A. Air Movement and Control Association International, Inc. (AMCA):
 - 1. 500D: Laboratory Methods of Testing Dampers for Rating
 - 2. 511: Certified Ratings Program Product Rating manual for Air Control Devices
- B. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code
- C. ASTM International (ASTM):
 - 1. A653: Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 2. B211: Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire

D. National Fire Protection Association (NFPA):

1. 70: National Electrical Code

1.03 DEFINITIONS:

- A. DDC: Direct-digital control
- B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product, including the following:
 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 3. Product description with complete technical data, performance curves, and product specification sheets.
 4. Installation instructions, including factors affecting performance.
- C. Shop Drawings:
 1. Include plans, elevations, sections, and mounting details.
 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
 4. Include diagrams for air and process signal tubing.
 5. Include diagrams for pneumatic signal and main air tubing.

D. Delegated-Design Submittal:

1. Schedule and design calculations for control dampers and actuators, including the following.
 - a. Flow at project design and minimum flow conditions.
 - b. Pressure drop across damper at project design and minimum airflow conditions.
 - c. Maximum close-off pressure.
 - d. Torque required at worst case condition for sizing actuator.
 - e. Actuator selection indicating torque provided.

E. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

F. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

1.05 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.06 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.07 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.08 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 MOTORIZED THERMALLY INSULATED CONTROL DAMPERS:

- A. Extruded aluminum (6063-T5) damper frame shall not be less than 0.08 inches in thickness. Damper frame shall be 4 inches deep x 1 inch, with duct mounting flanges on both sides of frame. Damper frame shall have a 2-inch mounting flange on the rear of the damper, when installed as Extended Rear Flange install type. Frame to be assembled using zinc-plated steel mounting fasteners.
- B. Blades shall be a maximum of 6 inches deep extruded aluminum (6063-T5) air-foil profiles with a minimum wall thickness of 0.06 inches. Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55 (tested to AAMA 1502.7 Test Method).
- C. Blade seals shall be extruded EPDM, secured in an integral slot within the aluminum blade extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals will not be approved.
- D. Frame seals shall be extruded silicone, secured in an integral slot within the aluminum frame extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Metallic compression type jamb seals will not be approved.
- E. Bearings shall be a dual bearing system composed of a Celcon inner bearing (fixed around a 0.437-inch aluminum hexagon blade pivot pin), rotating within a polycarbonate outer bearing inserted in the frame. Single axle bearing, rotating in an extruded or punched hole shall not be acceptable.
- F. Hexagonal control shaft shall be 0.437-inches. It shall have an adjustable length and shall be an integral part of the blade axle. A field-applied control shaft shall not be acceptable. All parts shall be zinc-plated steel.
- G. Linkage hardware shall be aluminum and corrosion-resistant zinc-plated steel, installed in the frame side, out of the airstream, and accessible after installation. Linkage hardware shall be complete with cup-point trunnion screws to prevent linkage slippage. Linkage that consists of metal rubbing metal will not be approved.
- H. Dampers shall be designed for operation in temperatures ranging from -40 degrees F to 212 degrees F.
- I. Dampers shall be AMCA rated for Leakage Class 1A at 1-inch water gage static pressure differential. Standard air leakage data to be certified under the AMCA Certified Ratings Program.
- J. Dampers shall be custom made to required size, with blade stops not exceeding 1.25 inches in height.

- K. Dampers shall be opposed blade action for modulating airflow control and parallel blade for two position open – close action.
- L. Standard of Acceptance: TAMCO Series 9000 thermally insulated damper
- M. Manufacturers:
 - 1. Ruskin
 - 2. Tamco
 - 3. Nailor
 - 4. Or equal

2.02 MOTORIZED CONTROL DAMPERS:

- A. Extruded aluminum (6063-T5) damper frame shall not be less than 0.08 inches in thickness. Damper frame shall be 4 inches deep x 1 inch, with duct mounting flanges on both sides of frame. Damper frame shall have a 2-inch mounting flange on the rear of the damper, when installed as Extended Rear Flange install type. Frame to be assembled using zinc-plated steel mounting fasteners.
- B. Blades shall be maximum 6 inches deep extruded aluminum (6063-T5) air-foil profiles with a minimum wall thickness of 0.06 inches.
- C. Blade seals shall be extruded EPDM, secured in an integral slot within the aluminum blade extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals will not be approved.
- D. Frame seals shall be extruded silicone, secured in an integral slot within the aluminum frame extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Metallic compression type jamb seals will not be approved.
- E. Bearings shall be a dual bearing system composed of a Celcon inner bearing (fixed around 0.437 inch aluminum hexagon blade pivot pin, rotating within a polycarbonate outer bearing inserted in the frame. Single axle bearing, rotating in an extruded or punched hole shall not be acceptable.
- F. Hexagonal control shaft shall be 0.437 inch. It shall have an adjustable length and shall be an integral part of the blade axle. A field-applied control shaft shall not be acceptable. All parts shall be zinc-plated steel.
- G. Linkage hardware shall be aluminum and corrosion-resistant zinc-plated steel, installed in the frame side, out of the airstream, and accessible after installation. Linkage hardware shall be complete with cup-point trunnion screws to prevent linkage slippage. Linkage that consists of metal rubbing metal will not be approved.

- H. Dampers shall be designed for operation in temperatures ranging from -40 degrees F to 212 degrees F.
- I. Dampers shall be AMCA rated for Leakage Class 1A at 1 inch water gage static pressure differential. Standard air leakage data to be certified under the AMCA Certified Ratings Program.
- J. Dampers shall be custom made to required size, with blade stops not exceeding 1.25 inches in height.
- K. Dampers shall be opposed blade action for standard control and parallel blade for two mixing box applications.
- L. Standard of acceptance: TAMCO Series 1000 Air-Foil Control Damper
- M. Manufacturers:
 - 1. Ruskin
 - 2. Tamco
 - 3. Nailor
 - 4. Or equal

2.03 DAMPER OPERATORS:

- A. Electronic Operators for Modulating Damper:
 - 1. Fail-safe spring return, 24 VAC operating voltage, 0 to 10 VDC input signal, 0 to 10 VDC position output signal, seventy (70) seconds maximum running time for 90 degrees opening and thirty (30) seconds maximum closing time.
 - 2. Provide sufficient damper motors to achieve unrestricted movement, with a minimum of one damper operator per damper section.
 - 3. Provide manual override gear release or crank.
 - 4. For modulating actuators provide actuator with 0-10V feedback proportional to damper position.
 - 5. Provide position indicator.
 - 6. Provide two (2) auxiliary switches for position proofing, one (1) at 10 degrees rotation and one (1) adjustable up to 90 degrees rotation.
 - 7. Unless otherwise shown on the Drawings, operators to be provided and set up such that all return air dampers are normally open (fail open) and exhaust and outdoor air dampers fail normally closed (fail closed).

8. Provide “fail safe”, spring return, direct coupled type, 24 volt or 120 volt A.C. operators with accessories as required, each suitable in all respects for the application.
9. Provide Class 1 Division 2 or Class 1 Division 1 rated actuators or explosion-resistant enclosures where required.
10. All actuators provided shall be from a single manufacturer.
11. Acceptable manufacturers:
 - a. Belimo Aircontrols Inc.
 - b. Johnson Controls Inc.
 - c. Siemens Building Technologies Inc.
 - d. Or equal

B. Electronic Operators for Two Position Damper:

1. Spring return, 24 VAC operating voltage, seventy (70) seconds maximum running time for 90 degrees opening and thirty (30) seconds maximum closing time.
2. Provide sufficient damper motors to achieve unrestricted movement, with a minimum of one damper operator per damper section.
3. Provide manual override gear release or crank.
4. Provide position indicator.
5. Provide two (2) auxiliary switches for position proofing, one (1) at 10 degrees rotation and one (1) adjustable up to 90 degrees rotation.
6. Provide Class 1 Division 1 or 2 rated actuators or explosion-resistant enclosures where required

2.04 PERFORMANCE REQUIREMENTS:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- C. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

D. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
 - a. Hazardous Locations: Explosion-proof rating for condition

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONTROL-DAMPER APPLICATIONS:

- A. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
 1. Rectangular Exhaust Air Duct Applications: Rectangular dampers with galvanized airfoil blades. Insulated rectangular dampers for non ducted applications.
 2. Rectangular Outdoor Air Duct Applications: Rectangular dampers with galvanized airfoil blades. Insulated rectangular dampers for non-ducted applications.
 3. Rectangular Return Air Duct Applications: Rectangular dampers with galvanized airfoil blades.
 4. Rectangular Supply Air Duct Applications: Rectangular dampers with galvanized airfoil blades.

3.03 INSTALLATION, GENERAL:

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment..

- C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Seal penetrations made in fire-rated and acoustically rated assemblies.
- E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Laboratory exhaust airstreams
 - b. Process exhaust airstreams
 - c. Odor Control Systems
 - 3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
 - 4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRIC POWER:

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install raceways. Comply with requirements in Section 26 05 33.

3.05 CONTROL DAMPERS:

- A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 23 33 00.

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.06 CONNECTIONS:

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 26 05 26.

3.07 IDENTIFICATION:

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53.

- B. Install engraved phenolic nameplate with damper identification on damper.

3.08 CHECKOUT PROCEDURES:

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.

4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.09 ADJUSTMENT, CALIBRATION, AND TESTING:

- A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.
- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

3.10 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 09 93

AUTOMATIC CONTROL SEQUENCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide control sequences for HVAC systems, subsystems, and equipment as indicated and in compliance with Contract Documents.

1.02 DEFINITIONS:

- A. Control Sequences: Manner and method by which automatic temperature controls function. Requirements for each type of operation are described in this section
- B. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA)
- C. BAS: Building automation system
- D. Binary Output: On/off output signal or contact closure
- E. Digital Output: Data output that must be interpreted digitally
- F. Manual Mode: Mode or position-controlled device assumes when under manual control. Unless otherwise specified, manual mode implied and affects only device for which manual mode or position identified
- G. Normal Mode: Mode or position-controlled device assumes without power
- H. Automatic Mode: Mode or position-controlled device assumes when under control of automatic system of controls

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data:
 - 1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
 - 2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

C. Shop Drawings:

1. Riser diagrams showing control network layout, communication protocol, and wire types.
2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed including adjustable range of control. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals. Clearly identify factory and field wiring requirements.
4. Control panel mounted devices including door mounted control elements.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 NOT USED

PART 3 - EXECUTION

3.01 HYDRONIC SYSTEM PRIMARY LOOP

A. Units Served:

1. 10-B-1
2. 10-B-2
3. 10-P-3
4. 10-P-4

B. General:

1. Integrate Boilers 10-B-1 and 10-B-2 with the automatic temperature control communication network.
2. Interlock Circulating Pump 10-P-4 with Boiler 10-B-1 to start prior to burner ignition and stop after an adjustable timed period upon burner shutdown.
3. Interlock Circulating Pump 10-P-3 with Boiler 10-B-2 to start prior to burner ignition and stop after an adjustable timed period upon burner shutdown.
4. Shut down Boilers 10-B-1 and 10-B-2 when hydronic system primary loop temperature exceeds adjustable hydronic system primary loop high limit temperature set-point of 200°F (manual reset).
5. Shut down Boiler 10-B-1 and Circulating Pump 10-P-4 on loss of flow (automatic reset) or low water level conditions (manual reset).
6. Shut down Boiler 10-B-2 and Circulating Pump 10-P-3 on loss of flow (automatic reset) or low water level conditions (manual reset).
7. Automatically rotate lead and lag boiler assignments weekly to equalize run times.

C. Manual Mode: On

1. Boiler 10-B-1 is energized.
2. Boiler 10-B-2 is energized.
3. Circulating Pump 10-P-4 is energized.
4. Circulating Pump 10-P-3 is energized.

D. Normal Mode: Off

1. Boiler 10-B-1 is de-energized.
2. Boiler 10-B-2 is de-energized.
3. Circulating Pump 10-P-4 is de-energized.
4. Circulating Pump 10-P-3 is de-energized.

E. Automatic Mode: On

1. Operating Controls: Provide each boiler with complete system of operation and safety controls by unit manufacturer.
2. Boiler Control: Enable boilers and associated pumps to operate year round.
3. If the secondary loop supply water temperatures is below the hydronic system secondary loop supply water temperature setpoint of 180°F (adj), energize lead hydronic boiler circulating pump and energize lead hydronic boiler to maintain primary loop supply water temperature setpoint.
4. If lead hydronic boiler is energized for an adjustable timed period and the secondary loop supply water temperature remains below the hydronic system secondary loop supply water temperature setpoint of 180°F (adj), energize lag hydronic boiler circulating pump and energize lag hydronic boiler to maintain primary loop supply water temperature setpoint.
5. Reverse procedure when heating demand is satisfied.

3.02 SECONDARY HOT WATER LOOP

A. Units Served:

1. 10-P-5
2. 10-P-6

B. General:

1. The secondary loop differential pressure is detected by a differential pressure sensor.
2. Automatically rotate lead and lag pump assignments to equalize run times.

C. Manual Mode: On

1. Secondary hot water pump 10-P-5 is energized.
2. Secondary hot water pump 10-P-6 is energized.

D. Normal Mode: Off

1. Secondary hot water pump 10-P-5 is de-energized.
2. Secondary hot water pump 10-P-6 is de-energized.

E. Automatic Mode:

1. Secondary loop lead pump 10-P-5 is energized and runs continuously.
2. If the secondary loop pump 10-P-5 is commanded to run but is not running, energize the secondary loop lag pump.
3. If the secondary loop differential pressure is below the adjustable secondary loop differential setpoint, increase the secondary loop pump speed.

3.03 PRIMARY CHILLED WATER LOOP

A. Units Served:

1. 10-C-1
2. 10-P-7
3. 10-P-8

B. General:

1. Integrate the Chiller 10-C-1 with the automatic temperature control communication network.
2. Circulating Pumps 10-P-7 and 10-P-8 shall be operated in a lead lag configuration.
3. On failure of the lead chiller pump, the lag chiller pump shall be energized and the lead chiller pump shall be de-energized.
4. Automatically rotate lead and lag chiller pump assignments weekly to equalize run times.
5. Shut down Chiller 10-C-1 and the lead chiller pump when chilled water system primary loop temperature is below the adjustable chilled water system primary loop low limit temperature setpoint of 35°F (manual reset).
6. Shut down Chiller 10-C-1 and the lead chiller pump on loss of flow (automatic reset) condition (manual reset).

C. Manual Mode: On

1. Chiller 10-C-1 is energized.

2. Circulating Pump 10-P-7 is energized.
3. Circulating Pump 10-P-8 is energized.

D. Normal Mode: Off

1. Chiller 10-C-1 is de-energized.
2. Circulating Pump 10-P-7 is de-energized.
3. Circulating Pump 10-P-8 is de-energized.

E. Automatic Mode: On

1. Operating Controls: Provide Chiller 10-C-1 with complete system of operation and safety controls by unit manufacturer.
2. Boiler Control: Enable Chiller 10-C-1, Circulating Pump 10-P-7, and Circulating Pump 10-P-8 when the outdoor air temperature is above the adjustable changeover temperature setpoint of 50°F (deenergized when outdoor air temperature is below changeover temperature setpoint).
3. If the secondary loop supply water temperatures is above the chilled water system secondary loop supply water temperature setpoint of 44°F (adj), energize lead chiller circulating pump and energize Chiller 10-C-1 cooling stages in sequence to maintain primary loop supply water temperature setpoint.
4. Reverse procedure when cooling demand is satisfied.

3.04 SECONDARY CHILLED WATER LOOP

A. Units Served:

1. 10-P-1
2. 10-P-2

B. General:

1. The secondary loop differential pressure is detected by a differential pressure sensor.
2. Circulating Pumps 10-P-1 and 10-P-2 shall be operated in a lead lag configuration.
3. Automatically rotate lead and lag pump assignments to equalize run times.

C. Manual Mode: On

1. Secondary chilled water pump 10-P-1 is energized.

2. Secondary chilled water pump 10-P-2 is energized.
- D. Normal Mode: Off
1. Secondary chilled water pump 10-P-1 is de-energized.
 2. Secondary chilled water pump 10-P-2 is de-energized.
- E. Automatic Mode:
1. Secondary loop lead pump is energized and runs continuously whenever the outdoor air temperature is above the adjustable changeover temperature on setpoint of 50°F (deenergized when outdoor air temperature is below the adjustable changeover off temperature setpoint of 45°F).
 2. If the secondary loop pump 10-P-5 is commanded to run but is not running, energize the secondary loop lag pump.
 3. If the secondary loop differential pressure differential pressure is below the adjustable secondary loop differential setpoint set point, increase the secondary loop pump speed (decrease speed when differential pressure is above setpoint).

3.05 VARIABLE AIR VOLUME AIR HANDLING UNIT

A. Units Served:

1. 10-AHU-1
2. 10-EF-1
3. 10-AMS-1
4. 10-CD-1 (exhaust)
5. 10-CD-2 (outdoor air mixing)
6. 10-CD-25 (return air mixing)

B. General

1. The Air Handler 10-AHU-1 supply fan and Return Fan 10-EF-1 shall run continuously during occupied periods unless unit is shut down on alarms.
2. The controller shall measure duct static pressure and shall modulate the Air Handler 10-AHU-1 supply and Return Fan 10-EF-1 speeds to maintain a duct static pressure set point per scheduled value – adjustable. The supply and return fan speeds shall not drop below 30% (adjustable).

3. Provide supply air temperature discharge reset function. The controller shall monitor the supply air temperature and shall maintain a supply air temperature reset based on zone cooling and heating requirements.
4. Provide automatic low temperature thermostat (freeze-stat) with sensing element serpentine on chilled water cooling coil to de-energize unit fan, close outside air damper, and broadcast an alarm to the BAS system upon sensing coil temperature of 32°F (adjustable).
5. The economizer shall be enabled whenever the outside air temperature is less than 65 degrees F, supply fan status is on, and the outside air temperature is less than the return air temperature.
6. Return air damper 10-CD-25 shall act in opposition to outdoor air damper 10-CD-2 and exhaust damper 10-CD-1.
7. Provide a smoke detector in return duct to de-energize air handler 10-AHU-1 supply fan, de-energize Return Fan 10-EF-1, and close outside air damper 10-CD-2 upon sensing a return smoke condition.
8. Occupied and unoccupied periods shall be user adjustable.
9. Two way heating control valve shall fail in the open position upon loss of power. Two way cooling control valves shall fail in the closed position upon loss of power.
10. The air handling unit 10-AHU-1 shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool down period while still achieving comfort conditions by the start of the scheduled occupied period.
11. A timed (3 hour) override control on room sensors shall allow an occupant to override the schedule and place the unit into occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to schedule.

C. Manual Mode: On

1. Air Handler 10-AHU-1 is energized.
2. Return Fan 10-EF-1 is energized.
3. Exhaust Damper 10-CD-1 is open.
4. Outdoor Air Damper 10-CD-2 is open.
5. Return Air Damper 10-CD-25 is closed.

D. Manual Mode: Off

1. Air Handler 10-AHU-1 is de-energized.
2. Return Fan 10-EF-1 is de-energized.
3. Exhaust Damper 10-CD-1 is closed.
4. Outdoor Air Damper 10-CD-2 is closed.
5. Return Air Damper 10-CD-25 is open.

E. Automatic Mode: Occupied

1. Air handling unit 10-AHU-1 and Return Fan 10-EF-1 are energized and operates continuously at fan speed set points as required to maintain supply ductwork static pressure setpoint with outdoor air damper 10-CD-2 positioned to bring in the minimum outdoor air amount as detected by the air measuring station 10-AMS-1.
2. When outdoor air dry bulb temperature exceeds adjustable changeover temperature set point of 55°F modulate two way chilled water and hot water heating valves to maintain adjustable supply air temperature of 55°F.
3. When outdoor air dry bulb temperature is less than the adjustable changeover temperature set point of 55°F modulate outdoor air damper to maintain a mixed air temperature of 55°F (adjustable). If mixed air temperature setpoint can't be maintained, modulate two way chilled water and hot water valves to achieve setpoint.

F. Automatic Mode: Unoccupied

1. Air handling unit 10-AHU-1 is de-energized and outdoor air damper 10-CD-2 is closed.
2. On a call for heating or cooling when outdoor air dry bulb temperature exceeds adjustable changeover temperature set point of 55°F modulate two way chilled water valve and hot water heating valves to maintain adjustable supply air temperature of 55°F.
3. On a call for heating or cooling when outdoor air dry bulb temperature is less than the adjustable changeover temperature set point of 55°F modulate outdoor air damper to maintain a mixed air temperature of 55°F (adjustable). If mixed air temperature setpoint can't be maintained, modulate two way chilled water and hot water valves to achieve setpoint. modulate two way chilled water valves.
4. De-energize air handler 10-AHU-1 when all zone temperature setpoints are satisfied.

3.06 SINGLE ZONE AIR HANDLING UNITS WITH RETURN FAN

A. Units served:

1. 10-AHU-2
2. 10-EF-2
3. 10-CD-8 (exhaust) (10-AHU-2)
4. 10-CD-7 (outdoor air mixing) (10-AHU-2)
5. 10-CD-16 (return air mixing) (10-AHU-2)
6. 10-AHU-4
7. 10-EF-4
8. 10-CD-4 (exhaust) (10-AHU-4)
9. 10-CD-3 (outdoor air mixing) (10-AHU-4)
10. 10-CD-21 (return air mixing) (10-AHU-4)

B. General

1. The supply fans and exhaust fans shall run continuously during occupied periods unless unit is shut down on alarms.
2. Provide supply air temperature discharge reset function. The controller shall monitor the supply air temperature and shall maintain a supply air temperature reset based on zone cooling and heating requirements.
3. Provide automatic low temperature thermostat (freeze-stat) with sensing element serpentine on chilled water cooling coil to de-energize unit fans, close respective outside air dampers, and broadcast an alarm to the BAS system upon sensing coil temperature of 32°F (adjustable).
4. The economizer shall be enabled whenever the outside air temperature is less than 65 degrees F, supply fan status is on, and the outside air temperature is less than the return air temperature.
5. Return air dampers shall act in opposition to their respective outdoor air dampers and exhaust dampers.
6. Provide a smoke detector in return duct to de-energize respective air handler supply fan and close associated outdoor air damper upon sensing a return air smoke condition.
7. Two way heating control valve shall fail in the open position upon loss of power. Two way cooling control valves shall fail in the closed position upon loss of power.

C. Manual Mode: On

1. Air handlers are energized.
2. Return fans are energized.
3. Exhaust dampers are open.
4. Outdoor air dampers are open.
5. Return air dampers are closed.

D. Manual Mode: Off

1. Air handlers are de-energized.
2. Return fans are de-energized.
3. Exhaust dampers are closed.
4. Outdoor air dampers are closed.
5. Return air dampers are open.

E. Automatic Mode: Occupied

1. Air handling units and respective return fans are energized and operate continuously with their respective outdoor air dampers in the minimum position.
2. On a call for heating or cooling when outdoor air dry bulb temperature exceeds adjustable changeover temperature set point of 55°F modulate respective two way chilled water valve and hot water heating valves to maintain adjustable supply air temperature of 55°F.
3. On a call for heating or cooling when outdoor air dry bulb temperature is less than the adjustable changeover temperature set point of 55°F modulate respective outdoor air damper to maintain a mixed air temperature of 55°F (adjustable). If mixed air temperature setpoint can't be maintained, modulate respective two way chilled water and hot water valves to achieve setpoint.

3.07 SINGLE ZONE AIR HANDLING UNITS WITHOUT RETURN FAN

A. Units Served:

1. 10-AHU-3
2. 10-CD-19 (exhaust)
3. 10-CD-20 (exhaust)
4. 10-CD-6 (outdoor air mixing)

5. 10-CD-5 (outdoor air pilot)
6. 10-CD-21 (return air mixing)

B. General

1. The Air handler 10-AHU-3 supply fan shall run continuously during occupied periods unless unit is shut down on alarms.
2. Provide supply air temperature discharge reset function. The controller shall monitor the supply air temperature and shall maintain a supply air temperature reset based on zone cooling and heating requirements.
3. Provide automatic low temperature thermostat (freeze-stat) with sensing element serpentine on chilled water cooling coil to de-energize unit fan, close outside air damper, and broadcast an alarm to the BAS system upon sensing coil temperature of 32°F (adjustable).
4. The economizer shall be enabled whenever the outside air temperature is less than 65 degrees F, supply fan status is on, and the outside air temperature is less than the return air temperature.
5. Return air damper 10-CD-21 shall act in opposition to outdoor air damper 10-CD-6 and exhaust dampers 10-CD-19 and 10-CD-20.
6. Provide a smoke detector in return duct to de-energize air handler 10-AHU-3 supply fan and close outside air damper 10-CD-6 upon sensing a return smoke condition.
7. Three way heating control valve shall fail in the full non-bypass position upon loss of power. Three way cooling control valves shall fail in the full bypass position upon loss of power.

C. Manual Mode: On

1. Air Handler 10-AHU-3 is energized.
2. Exhaust Damper 10-CD-19 is open.
3. Exhaust Damper 10-CD-19 is open.
4. Outdoor Air Damper 10-CD-5 is open.
5. Outdoor Air Damper 10-CD-6 is open.
6. Return Air Damper 10-CD-21 is closed.

D. Manual Mode: Off

1. Air Handler 10-AHU-3 is de-energized.

2. Exhaust Damper 10-CD-19 is closed.
3. Exhaust Damper 10-CD-19 is closed.
4. Outdoor Air Damper 10-CD-5 is closed.
5. Outdoor Air Damper 10-CD-6 is closed.
6. Return Air Damper 10-CD-21 is open.

E. Automatic Mode: Occupied

1. Air handling unit 10-AHU-3 is energized and operates continuously with outdoor air pilot damper 10-CD-5 open and outdoor air damper 10-CD-6 set to the minimum position.
2. On a call for heating or cooling when outdoor air dry bulb temperature exceeds adjustable changeover temperature set point of 55°F modulate three way chilled water and hot water heating valves to maintain adjustable supply air temperature of 55°F.
3. On a call for heating or cooling when outdoor air dry bulb temperature is less than the adjustable changeover temperature set point of 55°F modulate outdoor air damper 10-CD-6 to maintain a mixed air temperature of 55°F (adjustable). If mixed air temperature setpoint can't be maintained, modulate three way chilled water and hot water valves to achieve setpoint.

3.08 VARIABLE AIR VOLUME (VAV) REHEAT BOXES

A. Units Served:

1. 10-V-1
2. 10-V-2
3. 10-V-3
4. 10-V-4
5. 10-V-7

B. General:

1. Temperature Sensors shall include local temperature display, a space temperature setpoint selector, and an unoccupied override selector to temporarily change the control sequence mode to occupied during the unoccupied mode of operation for a timed period that is manually adjustable by software setting.
2. VAV Reheat Box actuators shall provide a damper position indicating signal.

3. Minimum and maximum VAV Reheat Box airflow setpoints shall be manually adjustable by software setting.

C. Hand Mode:

1. VAV Reheat Box is in user selectable position with heating valve in user selected position.

D. Off Mode:

1. VAV Reheat Box is in minimum airflow position with heating valves closed.

E. Auto Mode:

1. Modulate VAV Reheat Box toward the maximum airflow position when respective temperature sensors detect a corresponding space temperature above the cooling space temperature setpoint.
2. Modulate VAV Reheat Box damper toward the minimum airflow position and modulate the heating valve toward the open position in sequence when respective Temperature Sensor detects a space temperature below the corresponding adjustable space temperature setpoint. Modulate the heating valve toward the closed position and the VAV Reheat Box damper toward the open position in sequence when the respective space temperature sensor detects space temperature above corresponding adjustable space temperature setpoint.

3.09 MECHANICAL ROOM 202

A. Units Served:

1. 10-BC-1
2. 10-BC-2
3. 10-CD-29 (outside air)
4. 10-CD-10 (exhaust) (10-EF-5)
5. 10-EF-5

B. General

1. Provide supply air temperature discharge reset function. The controller shall monitor the supply air temperature and shall maintain a supply air temperature reset based on zone cooling and heating requirements.
2. Two way heating control valve shall fail in the open position upon loss of power. Two way cooling control valves shall fail in the closed position upon loss of power.

C. Manual Mode: On

1. Blower coil 10-BC-1 is energized.
2. Blower coil 10-BC-2 is energized
3. Outdoor Air Damper 10-CD-29 is opened.
4. Exhaust Air Damper 10-CD-10 is opened.
5. Exhaust Fan 10-EF-5 is energized.

D. Manual Mode: Off

1. Blower coil 10-BC-1 is de-energized.
2. Blower coil 10-BC-2 is de-energized
3. Outdoor Air Damper 10-CD-29 is closed.
4. Exhaust Air Damper 10-CD-10 is closed.
5. Exhaust Fan 10-EF-5 is de-energized.

E. Automatic Mode: Occupied

1. If temperature is above set point, first stage, untempered cooling system energizes 10-EF-5, opens 10-CD-29, and opens 10-CD-10. If temperature is still above set point, second stage cooling energizes 10-BC-1 and 10-BC-2.
2. If temperature is below set point, first stage untempered heating systems de-energizes 10-EF-5, closes 10-CD-29, and closes 10-CD-10. If temperature is still below set point, second stage heating energizes 10-BC-1 and 10-BC-2.

3.10 TOILET 115 AND TOILET 116

A. Units Served:

1. 10-V-5
2. 10-EF-11
3. 10-EF-12

B. Hand Mode:

1. VAV Reheat Box 10-V-5 is in user selectable position with heating valve in user selected position.

2. Exhaust Fan 10-EF-11 is energized.
3. Exhaust Fan 10-EF-12 is energized.

C. Off Mode:

1. VAV Reheat Box 10-V-5 is in minimum airflow position with heating valve closed.
2. Exhaust Fan 10-EF-11 is de-energized.
3. Exhaust Fan 10-EF-12 is de-energized.

D. Auto Mode:

1. Interlock Exhaust Fans 10-EF-11 and 10-EF-12 with their respective space light switch or occupancy sensor to run when occupied or lit.
2. Set VAV Reheat Box 10-V-5 minimum position to 30% when both exhaust fans are off; 50% when one fan is running; and 100% when both fans are running.
3. Modulate VAV Reheat Box 10-V-5 toward the maximum airflow position when space temperature sensor detects a space temperature above the adjustable space temperature setpoint.
4. Modulate VAV Reheat Box 10-V-5 damper toward the minimum airflow position and modulate the heating valve toward the open position in sequence when space temperature sensor detects a space temperature below the adjustable space temperature setpoint. Modulate the heating valve toward the closed position and the VAV Reheat Box 10-V-5 damper toward the open position in sequence when the space temperature sensor detects a space temperature above adjustable space temperature setpoint.

3.11 LAB 111

A. Units Served:

1. 10-V-6
2. Lab Hood
3. 10-EF-3
4. 10-CD-9

B. Hand Mode:

1. VAV Reheat Box 10-V-6 is in user selectable position with heating valve in user selected position.

C. Off Mode:

1. VAV Reheat Box 10-V-6 is in minimum airflow position with heating valve closed.
2. Exhaust Fan 10-EF-3 is energized.
3. Control Damper 10-CD-9 is open.

D. Auto Mode:

1. Energize Exhaust Fan 10-EF-3 and open Exhaust Damper 10-CD-9 when lab hood mounted fan switch is in the on position (fan de-energized and damper closed when switch is in the off position).
2. Set VAV Reheat Box 10-V-6 minimum position to 30% when both exhaust fans are off; 50% when one fan is running; and 100% when both fans are running.
3. Modulate VAV Reheat Box 10-V-6 toward the maximum airflow position when space temperature sensor detects a space temperature above the adjustable space temperature setpoint.
4. Modulate VAV Reheat Box 10-V-6 damper toward the minimum airflow position and modulate the heating valve toward the open position in sequence when space temperature sensor detects a space temperature below the adjustable space temperature setpoint. Modulate the heating valve toward the closed position and the VAV Reheat Box 10-V-6 damper toward the open position in sequence when the space temperature sensor detects space temperature above adjustable space temperature setpoint.

3.12 CITRIC ACID 127, COAGULANT 126, AND OZONE QUENCH 125

A. Units Served:

1. 10-EF-6
2. 10-EF-7
3. 10-EF-8
4. 10-CD-11 (exhaust) (10-EF-6)
5. 10-CD-12 (exhaust) (10-EF-7)
6. 10-CD-13 (exhaust) (10-EF-8)
7. 10-CD-11 (outdoor air) (10-EF-9)
8. 10-CD-12 (outdoor air) (10-EF-10)

9. 10-CD-13 (outdoor air) (10-EF-11)

B. General:

1. Exhaust fans shall run continuously with their respective outdoor air and exhaust air dampers in the open position unless shut down on alarms.

C. Manual Mode: On

1. Exhaust fans are energized.
2. Outdoor air dampers are open.
3. Exhaust dampers are open.

D. Manual Mode: Off

1. Exhaust fans are de-energized.
2. Outdoor air dampers are closed.
3. Exhaust dampers are closed.

E. Automatic Mode: On

1. Exhaust fans are energized and run continuously.
2. Respective outdoor air dampers and exhaust dampers are open.

3.13 OZONE GENERATION 124

A. Units Served:

1. 10-CD-14 (reclaim)
2. 10-CD-15 (exhaust air)
3. 10-CD-16 (reclaim)
4. 10-CD-17 (exhaust air)
5. 10-CD-18 (exhaust air) (10-EF-9)
6. 10-CD-26 (outside air)
7. 10-CD-27 (outside air)
8. 10-EF-9

B. General

1. Exhaust Fan 10-EF-9 shall run continuously with outdoor air damper 10-CD-27 in minimum position and exhaust damper 10-CD-18 in the open position unless shut down on alarms.
 - a. Set outdoor air damper 10-CD-27 minimum position to 10% when both process chillers are off. Set outdoor air damper 10-CD-27 minimum position to fully closed.
2. Interlock Outdoor Air Dampers 10-CD-26 and 10-CD-27 each with a Process Chiller to be open when their respective Process Chiller is running (closed when respective chiller not running).
3. Interlock Exhaust Dampers 10-CD-15 and 10-CD-17 each with a Process Chiller to be open when their respective Process Chiller is running (closed when respective chiller not running).
4. Reclaim air dampers shall act in opposition to their respective outdoor air damper and exhaust dampers.
5. An ozone detector shall be provided by others to detect a high ozone concentration condition.
 - a. BAS shall accept a high ozone concentration alarm from the ozone detector for monitoring purposes.

C. Manual Mode: On

1. 10-EF-9 is energized.
2. 10-CD-14 (reclaim) is closed.
3. 10-CD-15 (exhaust air) is opened.
4. 10-CD-16 (reclaim) is closed.
5. 10-CD-17 (exhaust air) is opened.
6. 10-CD-18 (exhaust air) (10-EF-9) is opened.
7. 10-CD-26 (outside air) is opened.
8. 10-CD-27 (outside air) is opened.

D. Manual Mode: Off

1. 10-EF-9 is de-energized.
2. 10-CD-14 (reclaim air) is closed.

3. 10-CD-15 (exhaust air) is closed.
4. 10-CD-16 (reclaim) is closed.
5. 10-CD-17 (exhaust air) is closed.
6. 10-CD-18 (exhaust air) (10-EF-9) is closed.
7. 10-CD-26 (outside air) is closed.
8. 10-CD-27 (outside air) is closed.

E. Automatic Mode:

1. Exhaust Fan 10-EF-9 shall run continuously with outdoor air damper 10-CD-27 in minimum position and exhaust damper 10-CD-18 in the open position.
2. Open outdoor air damper 10-CD-26 and exhaust damper 10-CD-17 when the west process chiller is running (closed when chiller is off).
 - a. When the space temperature sensor detects a space temperature below the adjustable space temperature setpoint, modulate reclaim damper 10-CD-14 toward the open position, outdoor air damper 10-CD-27 toward the minimum position, and exhaust damper 10-CD-15 toward the closed position.
 - b. Reverse procedure when call for heating is satisfied.
3. Open outdoor air damper 10-CD-27 and exhaust damper 10-CD-15 when the east process chiller is running (closed when chiller is off).
 - a. When the space temperature sensor detects a space temperature below the adjustable space temperature setpoint, modulate reclaim damper 10-CD-16 toward the open position, outdoor air damper 10-CD-28 toward the minimum position, and exhaust damper 10-CD-17 toward the closed position.
 - b. Reverse procedure when call for heating is satisfied.

3.14 CHLORINE GAS STORAGE 123

A. Units Served:

1. 10-CD-21 (exhaust) (10-EF-10)
2. 10-CD-28 (outdoor air)
3. 10-EF-10

B. General

1. Exhaust fan shall exhaust 13,500 cubic feet of air per minute when space is occupied. Noted as “high” setting.
 2. Exhaust fan shall exhaust 1,350 cubic feet of air per minute in normal, unoccupied condition. Noted as “low” setting.
 3. Exhaust fan shall de-energize and 10-CD-21 and 10-CD-28 shall close upon high Chlorine content reading from Chlorine sensor. Chlorine scrubber shall be energized.
- C. Manual Mode: On
1. Exhaust fan 10-EF-10 is energized and is set to high.
 2. Exhaust Damper 10-CD-21 is open.
 3. Outdoor Air Damper 10-CD-28 is open.
- D. Manual Mode: Off
1. Exhaust fan 10-EF-10 is de-energized.
 2. Exhaust Damper 10-CD-21 is closed.
 3. Outdoor Air Damper 10-CD-28 is closed.
- E. Automatic Mode: Occupied
1. Exhaust fan 10-EF-10 is energized and is set to high.
 2. Exhaust Damper 10-CD-21 is open.
 3. Outdoor Air Damper 10-CD-28 is open.
- F. Automatic Mode: Unoccupied
1. Exhaust fan 10-EF-10 is energized and is set to low.
 2. Exhaust Damper 10-CD-21 is open.
 3. Outdoor Air Damper 10-CD-28 is open.
- 3.15 HYDRONIC UNIT HEATERS
- A. Units Served
1. 10-UH-1 thru 10-UH-14
- B. General:

1. Two way control valve shall fail open upon loss of power.
- C. Normal Mode: Off
1. Fan: Off
 2. Control Valve: Closed.
- D. Automatic Mode: On.
1. When the space thermostat detects a space temperature below the adjustable space temperature setpoint, the two way control valve moves to the open position. The unit heater fan energizes when the hot water return aquastat senses a warm coil. When the space thermostat detects a space temperature above the adjustable space temperature setpoint, the two way control valve moves to the closed position. The unit heater fan de-energizes when the hot water return aquastat senses a cold coil.

3.16 ELECTRIC UNIT HEATER

- A. Units Served:
1. 10-EUH-1
 2. 10-EUH-2
 3. 10-EUH-3
 4. 10-EUH-4
- B. Normal Mode: Off
1. Fan: Off
 2. Electric Heating Stages: Deenergized.
- C. Automatic Mode: On.
1. When the space thermostat detects a space temperature below the adjustable space temperature setpoint, energize the fan and engage heating coil stages. When the space thermostat detects a space temperature above the adjustable space temperature setpoint, deenergize the fan and disengage heating coil stages.

3.17 BUILDING AUTOMATION SYSTEM

- A. The Building Automation System (BAS) shall monitor and provide at a minimum the following functions. The mechanical and temperature controls contractor are responsible for coordinating the communication and protocol between the BAS controller differing manufacture supplied controllers.

1. Monitor the following status points:
 - a. Boilers:
 - (1) Hot water supply temperatures
 - (2) Hot water return temperatures
 - (3) Boiler status (on-off)
 - (4) Run time
 - b. Hot water pumps:
 - (1) Pumps status (on-off)
 - (2) Hot water differential pressure
 - (3) Hot water differential pressure set point
 - (4) Hot water pump VFD speeds
 - (5) Run time
 - c. Air handling units:
 - (1) Air handling unit status (on-off)
 - (2) Supply, mixed, return, and outside air temperatures
 - (3) VFD status (% operating) supply and return air fans
 - (4) Damper positions
 - (5) Filter status
 - (6) Valve positions (chilled and hot water)
 - (7) Chilled and hot water inlet and outlet temperatures
 - (8) Supply and return air fan status (on-off)
 - (9) Airflow readings where applicable.
 - (10) Set points (supply and economizer mixed air temperatures)
 - (11) Occupied and unoccupied schedule
 - d. Air Cooled Chillers:

- (1) Chiller Status (on-off)
- (2) Chilled water supply temperature
- (3) Chilled water return temperature
- (4) Outside air temperature
- (5) Run time

e. Chilled Water Pumps:

- (1) Chilled water differential pressure
- (2) Chilled water pump status (on-off)
- (3) Chilled water pumps VFD speed
- (4) Chilled water differential pressure set point
- (5) Run time

f. VAV Reheat Boxes:

- (1) Damper position
- (2) Hot water valve position
- (3) Room sensor set points (heating and cooling)
- (4) Airflow readings
- (5) Zone temperature
- (6) Occupied and unoccupied schedules
- (7) Discharge air temperature
- (8) Hot water supply and return temperatures

g. Space sensors:

- (1) Set points
- (2) Space temperature
- (3) Unoccupied zone override

2. Monitor the following alarm points:

- a. Boilers:
 - (1) Failure (commanded on – but status is off)
 - (2) Low water level
 - (3) High and low primary hot water supply temperature readings
- b. Hot Water Pumps:
 - (1) Failure (commanded on – but status is off)
 - (2) VFD failure
 - (3) Runtime exceeded
 - (4) High hot water differential pressure
 - (5) Low hot water differential pressure
- c. Air handling units:
 - (1) Failure (commanded on – but status is off)
 - (2) High and low supply air static pressure
 - (3) Supply fan and VFD failure
 - (4) Return fan and VFD failure
 - (5) High and low supply & return air temperatures
 - (6) High and low mixed air temperature
 - (7) Freezestat
 - (8) Return air smoke detector
- d. Air Cooled Chiller:
 - (1) Chiller failure – commanded on, but the status is off.
 - (2) Lead chiller failure – the lead chiller is in failure and the lag chiller is on.
 - (3) High and low chilled water supply temperatures
 - (4) High and low chilled water return temperatures

- e. Chilled Water Pumps:
 - (1) Pump failure – commanded on, but the status is off.
 - (2) VFD faults
 - (3) Runtime exceeded
 - (4) High chilled water differential pressure
 - (5) Low chilled water differential pressure
- f. VAV Reheat Boxes:
 - (1) Airflow sensor failure
 - (2) Valve failure
 - (3) Damper failed to open or close
 - (4) High and low space temperature (adjustable limits from space set points)
 - (5) High discharge air temperature
- g. Space sensors:
 - (1) Failure
 - (2) High and low space temperatures

END OF SECTION

SECTION 23 11 23

FACILITY NATURAL GAS PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide new and modify existing gas piping systems, complete and ready for operation. The Work of this Section shall include all labor, materials, tools, equipment, and appurtenances, and performing all operations necessary to furnish and install complete and operable systems in accordance with this Section of these Specifications, the Contract Drawings, and the codes and standards listed herein.
- B. Coordinate with Dominion Energy as to any Local restrictions or requirements relative to the installation of the system.
- C. Limits of Work shall be as indicated on the Contract Drawings. Items of Work shall consist of the following:
 - 1. All gas piping downstream of gas meter/regulator outlets. Meter/regulators and gas piping upstream of meter/regulators will be furnished and installed by the local gas utility in accordance with their rules and regulations.
 - 2. Painting of pipe, fittings, and valves.

1.02 REFERENCES:

- A. Except as specified herein, the latest edition of the standards listed below form a part of this Specification to the extent referenced in this Section. Where earlier editions of standards are adopted as referenced in applicable codes, those shall govern. The publications are referred to within the text by the basic designation only.
- B. In each of the standards referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears.
- C. American National Standards Institute (ANSI):
 - 1. B109.1: Diaphragm-Type Gas Displacement Meters (Under 500 Cubic Feet per Hour Capacity)
 - 2. B109.2: Diaphragm Type Gas Displacement Meters (500 Cubic Feet per Hour Capacity and Over)
 - 3. B109.3: Rotary Type Gas Displacement Meters

4. LC-1: Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing
5. LC-4: Press-Connect Metallic Fittings For Use in Fuel Gas Distribution Systems
6. Z21.24: Connectors for Gas Appliances
7. Z21.41: Quick-Disconnect Devices for Use with Gas Fuel Appliances
8. Z21.45: Flexible Connectors of Other Than All-Metal Construction for Gas Appliances
9. Z21.69: Connectors for Movable Gas Appliances
10. Z21.70: Earthquake Actuated Automatic Gas Shutoff Systems
11. Z21.80: Line Pressure Regulators
12. Z21.90: Gas Convenience Outlets and Optional Enclosures

D. American Society of Mechanical Engineers (ASME):

1. B1.1: Unified Inch Screw Threads (UN and UNR Thread Form)
2. B1.20.1: Pipe Threads, General Purpose, Inch
3. B2.1: Pipe Threads
4. B16.3: Malleable Iron Threaded Fittings Class 150 and 300.
5. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
6. B16.9: Factory-Made Wrought Steel Buttwelding Fittings
7. B16.11: Forged Fittings, Socket-Welding and Threaded
8. B16.38: Large Metallic Valves for Gas Distribution (Manually Operated, NPS 2 1/2 to 12, 125 psig Maximum)
9. B16.39: Malleable Iron Threaded Pipe Unions
10. B16.40: Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
11. B18.2.1: Square and Hex Bolts and Screws, Inch Series
12. B18.2.2: Square and Hex Nuts
13. B31.8: Gas Transmission and Distribution Piping Systems

E. ASTM International (ASTM):

1. A36: Carbon Structural Steel
2. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. A182: Standard Specification for Forged or Rolled Alloy and Stainless-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
4. A194: Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service or Both
5. A403: Standard Specification for Wrought Austenitic Stainless-Steel Piping Fittings
6. B61: Standard Specification for Steam or Valve Bronze Castings
7. B88: Standard Specification for Seamless Copper Water Tube
8. D2513: Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
9. D2517: Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
10. D2683: Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
11. F1973: Standard Specification for Factory Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide 11 (PA11) and Polyamide 12 (PA12) Fuel Gas Distribution Systems

F. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):

1. SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Application, and Installation

G. Sheet Metal And Air Conditioning Contractors' National Association (SMACNA):

1. SMACNA Seismic Restraint Mnl: Seismic Restraint Manual: Guidelines for Mechanical Systems

H. U.S. National Archives And Records Administration (NARA):

1. 49 CFR 192: Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

I. National Fire Protection Association (NFPA):

1. NFPA 54: National Fuel Gas Code

J. Manufacturers' Standardization Society (MSS):

1. SP-43: Wrought Stainless Steel Butt-Welding Fittings

K. Fuel Gas Code 2015 of Utah (Adopts with Amendments the International Fuel Gas Code 2015 (IFGC 2015))

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Shop Drawings: Coordination Drawings - Prepare as specified in Paragraph "Cooperation and Coordination with Other Trades" of this Section.

C. Product Data: Annotate descriptive data to show the specific manufacturer, model, type, size capacity, curves, wiring diagrams, options, etc. of each item.

1. Pipe and fittings

2. Casings

3. Warning and identification tape

4. Valves

5. Valve boxes

6. Gas equipment connectors

7. Meters

8. Regulators

9. Pipe hangers and supports

10. Access panels

D. Certification: Submit documentation certifying completion of the following items in compliance with this Section.

1. Metal welding inspection

2. PE fusion welding inspection

3. Piping pressure tests

4. System purging

- E. Certificates and Licenses: Prepare as specified in Part 1 of this Section.
 - 1. Qualifications of Installer
 - 2. Qualifications of Construction Supervisor
 - F. Manufacturer's Instructions: Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart.
 - 1. PE pipe and fittings
 - G. Operation and Maintenance Manuals: Prepare manuals in accordance with Section 01 78 23.
 - 1. Valves
 - 2. Meters
 - 3. Regulators
 - H. Test Data: Submit piping system leakage test sheets as specified in Section 22 05 00.
 - I. Closeout Submittals:
 - 1. Record Drawings: Prepare as specified in Part 1 of this Section.
- 1.04 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Qualifications of Installer:
 - 1. Prior to installation, submit data showing the name and license of the installing contractor and that they have successfully installed systems of the same type and design as specified herein. Data shall include names and locations of at least two installations of such systems. Indicate type and design of each system and certify that each system has performed satisfactorily in the manner intended for not less than 18 months. The installing contractor shall be licensed to perform applicable gas piping systems installation in the State of Utah.
 - C. Qualifications of Welder:
 - 1. Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. The Authority Having Jurisdiction shall be notified 24 hours in advance of any required testing and the tests shall be performed at the work site. The welder or welding operator shall apply their assigned symbol near each weld they make as a permanent record. Prior to installation, submit data for acceptance showing the name and certification of each welder and welding operator to be used on the project. Submit each welder's

identification symbols, assigned number, or letter, used to identify work of the welder. Welders making defective welds after passing a qualification test shall be given requalification test and, upon failing to pass this test, shall not be permitted to work on this Contract.

- a. Steel Welder's Qualifications: Comply with ASME B31.8. Each steel welder shall have a copy of a certified ASME B31.8 qualification test report. Conduct a qualification test for each welder and submit results for acceptance.
- b. PE Welder's Qualifications: Supervising and installing personnel shall be trained by a PE pipe manufacturer's sponsored course of not less than one week duration, or present proof satisfactory to the Engineer that personnel are currently working in the installation of PE gas distribution lines. Conduct a qualification test for each welder and submit results for acceptance.
- c. Safety Standards: 49 CFR 192.

D. Qualifications of Construction Supervisor:

- 1. Provide a Construction Supervisor with a minimum of 5 years of experience in fuel gas piping construction supervision who shall be responsible for the installation of the Work of this Section of the Specifications. The Construction Supervisor shall be licensed to perform applicable fuel gas piping systems supervision in the State of Utah. Prior to installation, submit data for acceptance showing the name and license of the Construction Supervisor.

1.05 DELIVERY STORAGE AND HANDLING:

A. Comply with the requirements specified in Section 01 66 10.

B. Shipping:

- 1. All equipment, material and spare parts shall be shipped, stored, handled, and installed in such a manner as not to degrade quality, serviceability, or appearance. Equipment and material warranties shall not be voided by actions of the Contractor.

C. Receiving:

- 1. All equipment, material and spare parts shall be delivered to the site in original packages or containers bearing the manufacturer's labels and product identification.
- 2. Inspect for damage and correctness, and inventory items, upon delivery to site.

3. Store and safeguard equipment, material, and spare parts in accordance with manufacturer's recommendations.

1.06 SPECIAL REQUIREMENTS:

A. Refer to applicable sections of Division 1 with regard to providing the following:

1. Submittal of manufacturer's specifications, catalog data, descriptive matter, illustrations, diagrams, etc., including complete motor data for all equipment.
2. Nameplates
3. Foundations, installations, and grouting
4. Operating and maintenance instructions and parts lists
5. Lubricants
6. Special tools
7. Bolts, anchor bolts, and nuts
8. Concrete inserts
9. Sleeves
10. Electric motors
11. Voltage rating of motors
12. Equipment drive guards

1.07 COOPERATION AND COORDINATION WITH OTHER TRADES:

- A. Work shall be performed in cooperation with other trades on the project and so scheduled as to allow efficient completion of the project. Materials and equipment shall be installed as fast as conditions will permit and installed promptly when and as directed.
- B. Furnish to all other trades advance information on location and size of all concrete pads, chases, frames, boxes, sleeves, and openings needed for the Work, and furnish layout information and shop drawings necessary to permit other trades affected by the Work to install their work properly coordinated and without delay.
- C. Where there is evidence that Work installed interferes with the work of other Sections, assist in working out space conditions to make satisfactory adjustments.
- D. With the acceptance of the Engineer and without extra cost to the Owner, make reasonable modifications in Work specified under this Section of the Specifications

required to coordinate with normal structural interferences, or for proper execution of specified work.

- E. If work is installed before coordinated with other trades so as to cause interference with the work of such trades, make all necessary changes in Work under this Section of the Specifications at no additional cost to the Owner.
- F. Protect all materials and work of other trades from damage that may be caused by the Work required under this Section of the Specifications and be responsible for repairing any damages caused by such work without any additional cost to the Owner.
- G. Follow Drawings in layout work. Check Drawings of, and coordinate with, other trades to verify special provisions, installation requirements and spaces in which Work provided under this Section of the Specifications will be installed. Maintain maximum headroom or space conditions at all points. Where headroom or space conditions appear inadequate, notify the Engineer before proceeding.
- H. Prepare and submit for acceptance Coordination Drawings consisting of 3/8 inch = 1 foot-0 inches scale or larger working plans and sections, clearly showing how this Work is to be installed in relation to the work of other Sections. Coordination Drawings shall be based upon accepted equipment submittals.
- I. Attend regular coordination and job progress meetings required.

1.08 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION:

- A. All electrical apparatus and controls associated with equipment installed or modified under this Section, but which are not integral with the equipment served, shall be furnished under Division 26. All mounting and wiring of non-integral electrical apparatus and controls, and interconnecting wiring to equipment served will be done under Division 26.
- B. Access panels shall be furnished under this Section and installed by the trade responsible for the appropriate Section of the Specifications for the surface upon which the panels are mounted. Prepare a schedule showing location, size and function of all required access panels and deliver schedule to representatives of all installing trades.
- C. Inserts and anchor bolts shall be furnished under this Section and installed under Section 03 30 00. Prepare a schedule showing location, size and function of all required inserts and anchor bolts and deliver schedule to representative of the installing trade.
- D. Pipe sleeves shall be furnished under this Section and installed by the trade whose finished interior surfaces will be penetrated. Prepare a schedule showing location, size and function of all required pipe sleeves and deliver schedule to representatives of all installing trades.

1.09 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION:

- A. Gas meters and regulators will be furnished by the Gas Utility.

1.10 REMOVAL WORK:

- A. Particular care shall be taken to avoid creating hazards on the site or causing disruption of service in the adjoining buildings.
- B. All existing equipment indicated to be removed shall be done in a neat and workmanlike manner. All existing equipment indicated to be turned over to the Owner shall be presented to the Owner in good condition at a location designated by the Owner. All other equipment shall be removed from the premises and disposed of at an approved disposal or recycling facility.
- C. Remove all abandoned piping and equipment not built into building construction. Where ceilings or walls are removed all abandoned conduit and piping shall be removed and ends of live services capped. Abandoned elements built into walls or located above existing ceilings shall remain and ends capped and marked abandoned.
- D. Should any asbestos and/or asbestos related products or materials be encountered during the performance of the Work, stop work immediately and inform the Engineer and the Owner of the presence of asbestos.

1.11 ELECTRICAL WORK:

- A. All electrical apparatus and controls associated with equipment installed or modified under this Section, but which are not integral with the equipment served, shall be furnished under Division 26. All mounting and wiring of non-integral electrical apparatus and controls, and interconnecting wiring to equipment served will be done under Division 26.
- B. All equipment furnished under this Section requiring motors shall have motors factory furnished and installed by the manufacturer of the equipment served and shall be mounted and aligned so as to run free and true. Provide internal wiring and motors for mechanical equipment as an integral part of the equipment. Motor starters and contactors shall be factory-furnished and wired as an integral part of packaged mechanical equipment where indicated on the Contract Drawings. Disconnect switches, and all other motor starters and contactors shall be furnished, installed, and wired by Division 26.
- C. When motors and other associated electrical apparatus furnished are larger than sizes indicated on the Drawings, the cost of additional electrical service and related work shall be included under the Section that furnished that motor.

1.12 CODES, PERMITS AND FEES:

- A. Except for additional requirements as specified or indicated under the Work of this Section, materials, workmanship, and equipment shall conform to the governing edition of the following regulations, and agency requirements. In the standards referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears.
 - 1. State and Local Building Codes including, but not limited to, the Utah Fuel Gas Code and the 2018 International Building Code.
 - 2. Local Fire Department.
 - 3. Dominion Energy.
 - 4. Occupational Safety and Health Administration (OSHA).
 - 5. Any other local codes or requirements of Authorities Having Jurisdiction.
- B. Pay for all fees and give all notices, file all plans, obtain all permits and licenses, and obtain all necessary approvals from Authorities Having Jurisdiction. Deliver all certificates of inspection to the Authorities Having Jurisdiction. No work shall be covered before examination and approval by Authorities Having Jurisdiction. Replace imperfect or condemned work to conform to inspectional requirements, satisfactory to the Architect, Owner, Engineer, and Authorities Having Jurisdiction without extra cost to the Owner. If Work is covered before inspection and acceptance, pay costs of uncovering and reinstalling the covering, whether it meets contract requirements or not.

1.13 RECORD DRAWINGS:

- A. Prepare and maintain Record Drawing to meet the requirements of this Section of the Contract Specifications.
- B. As work progresses and for the duration of the Contract, maintain a complete and separate set of prints of Drawings at the job site at all times. On a daily basis, record work completed and all changes from original Drawings clearly and accurately, including work installed as a modification or addition to the original design such as change orders, instructions issued by the Engineer, or conditions encountered in the field. Record valve tags as they are installed. In addition, take photographs of all concealed equipment in gypsum board ceilings, shafts, underground (buried) piping routes and supports and other concealed, inaccessible work. At completion of work, make copies of photographs with written explanation on back. These shall become part of Record Drawings.
- C. Record drawings shall show record condition of pipe routing and sizes, valve locations, details and sections, riser diagrams, and control changes. Schedules shall show actual manufacturer and make and model numbers of final equipment installation. Remove all

superseded data to show the completed work. Accurately indicate the location, size, type, and elevation of new buried piping and their relationship to existing buried piping.

- D. The Record Drawings will be used as a guide for determining the progress of the Work installed. They shall be inspected on a regular basis and shall be corrected immediately if found inaccurate or incomplete. Requisitions for payment will not be accepted until the Record Drawings are accurate and up-to-date.
- E. At completion of Work prepare a complete set of marked-up Record Drawings on bond paper showing all systems as actually installed. The Contract Drawing electronic CAD files will be made available for this Contractor's use to serve as backgrounds for the Record Drawings. Provide all drawings necessary to show the required record information. Submit marked-up prints to the Engineer for comments as to compliance with this Section. Make all modifications so noted by the Engineer.
- F. Certify the accuracy of the Record Drawings. Record Drawings shall become the property of the Owner.
- G. When required by jurisdiction, submit the Record Drawings for approval by the Authority Having Jurisdiction in a form acceptable to the jurisdiction.

PART 2 - PRODUCTS

2.01 PIPE, FITTINGS AND JOINTS:

- A. Coated Black Steel - Welded Joints: "Yellow Jacket" Schedule 40 mild black carbon steel, ASTM A53, Grade B, factory coated with yellow plastic, mill or site beveled, and complete with forged steel butt welding fittings and welded joints. All bare metal surfaces are to be cleaned and corrosion protected with a suitable Denso primer and tape corrosion protection system.
- B. Polyethylene (Buried Piping): Safety yellow colored medium density polyethylene (MDPE) pipe shall be in accordance with ASTM D 2513, 100 psig working pressure, Standard Dimension Ratio (SDR), the ratio of pipe diameter to wall thickness, 11.5 maximum.
 - 1. Manufacturers:
 - a. Performance Pipe Driscopex 6500 Series
 - b. JM Eagle
 - c. ENDOT Industries, Inc. Yellow Gas Pipe
 - 2. Socket Fittings: Per ASTM D2683.
 - 3. Butt-Fusion Fittings: Per ASTM D2513, molded.

4. Buried Utility Warning and Identification Tape:

- a. Provide detectable aluminum-foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3-inch minimum width, color-coded yellow for natural gas, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED GAS PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material. Refer to Section 31 23 33 for details.
- b. Manufacturer shall be:
 - (1) Seton
 - (2) Reef Industries, Inc.
 - (3) Terra Tape Security Line Detectable
 - (4) Christy's
 - (5) Presco

5. Casing:

- a. Where indicated at railroad or other crossing, provide ASTM A53, galvanized pipe, Schedule 40, with extruded polyethylene coating.
- C. Uncoated Black Steel – Screwed Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with malleable cast iron screwed fittings to ANSI B2.1, and screwed joints.
- D. Uncoated Black Steel – Welded Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, mill or site beveled, complete with factory made forged steel butt welding fittings and welded joints.
- E. Copper-Uncoated: Type “K” seamless copper tubing to ASTM B88, hard temper with wrought copper capillary brazed joint type fittings to ASTM B61, and brazed joints made with “Sil-Fos” or “Sil-Fos 5” brazing alloy, or, soft temper with flared brass fittings of a single 45 degree flare type, forged or with a machined long nut and copper to copper threaded connectors, and, where required, flared brass copper to NPS adapters.
- F. Coated Copper: Type “K” soft temper as above but with a factory applied external yellow plastic coating approved by governing authorities.

- G. Flexible Stainless Steel: Flexible, CGA certified, 125 psi rated, gas-tight, convoluted stainless steel tubing factory jacketed with a bright yellow PVC coating which is continuously identified. The tubing is to be supplied in coils and is to be complete with factory attached stainless steel end fittings, and adapter unions, protective plates, and steel clamps. Acceptable products are:

1. Flex Pression Ltd. (Westburne) "GAZFLEX"
2. Tru-Flex Metal Hose Corp. "Pro-Flex"
3. Titeflex Corp. "Gastite"
4. Omega Flex Canada "TracPipe"

H. Aboveground Fittings:

1. Pipe: Black steel, ASTM A 53, Type E or F, Grade A or B, Schedule 40, threaded ends or plain end socket welded for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.
2. Threaded Fittings: ASME B16.3, black malleable iron.
3. Socket-Welding Fittings: ASME B16.11, forged steel.
4. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.
5. Unions: ASME B16.39, black malleable iron.
6. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1. Flange faces shall have integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.
 - a. Gaskets: Fluorinated elastomer, compatible with flange faces.
 - b. Bolting: Stainless steel; ASTM A 193, Grade B8M or B8MA, Type 316, for bolts; and ASTM A 194, Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts shall conform with ASME B18.2.1 and ASME B18.2.2 with coarse threads conforming to ASME B1.1, with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts and bolt-studs shall extend through the nuts and may have reduced shanks of a diameter not less than the diameter at roof of threads. Bolts shall have American Standard regular square or heavy hexagon heads. Nuts shall be American Standard heavy semi-finished hexagon.
7. Pipe Thread Paste or Tape: Anti-seize and sealant paste or tape of polytetrafluoroethylene (PTFE).

8. Welding Filler Metal: ASME B31.8.

I. Risers:

1. Manufacturer's standard anodeless riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating meeting the requirements of ASTM F1973. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide remote bolt-on or bracket or wall-mounted riser supports as indicated.
 - a. Manufacturer shall be:
 - (1) GF Central Plastics
 - (2) Elster Perfection

J. Transition Fittings:

1. Steel to Plastic (PE): As specified for "riser" except designed for steel-to-plastic with tapping tee or sleeve. Coat or wrap exposed steel pipe with heavy plastic coating.
2. Plastic to Plastic: Manufacturer's standard bolt-on (PVC to PE) plastic tapping saddle tee, UL listed for gas service, rated for 100 psig, and O-ring seals. Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support, O-ring seals, and rated for 150 psig gas service.

2.02 VALVES, BURIED:

A. Shutoff Valves:

1. Metallic ball valves, ANSI B16.33 corrosion-resisting steel, with threaded or flanged ends. Provide polytetrafluoroethylene (PTFE) seats.
2. PE ball or plug valves, ASME B16.40 and ASTM D 2513, Class C materials (PE 2306 or PE 3406), strength rating of Class 4 location with class factor of 0.20, and SDR matching PE pipe dimensions and working pressure.
 - a. Manufacturers:
 - (1) Poly-Valve
 - (2) Aqua-Fuse by CMF Global
 - (3) Lyall-Polytec
 - (4) GF Central Plastics

B. Valve Boxes:

1. Provide rectangular concrete valve box, sized large enough for removal of valve without removing box. Cast the word "Gas" into the box cover. Use valve box for areas as follows:
 - a. Roads and Traffic Areas: Heavy duty, cast iron cover.
 - b. Other Areas: Standard duty, concrete cover.

2.03 VALVES, ABOVEGROUND:

- A. Provide lockable valves where located outdoors and where otherwise indicated. Valves shall be of only one of the types specified herein below.
- B. Earthquake Automatic Gas Shutoff Valve:
 1. ANSI Z21.70 and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed.
 2. The valve shall provide automatic shut off when triggered by a magnitude 5.5 seismic event. Manually resettable on both sides of valve.
- C. Ball Type (1/4-inch to 4-inch diameter): minimum 450 psi WOG rated, 1/4 turn, full port non-lubricated brass ball valves, each complete with a Teflon PTFE seat, chrome plated solid ball, removable lever handle, and screwed ends. Acceptable products are:
 1. Neo Valves #525
 2. Kitz Corp. Code 58
 3. Toyo Valve Co. Fig. 5044A
 4. MAS B-3
 5. Nibco #T-FP-600
- D. Plug Type (4-inch to 8-inch diameter): Plain face flanged, Class 125, 1380 kPa rated, 1/4 turn, cast iron lubricated plug valves, each wrench operated and complete with cylindrical plug with lubricant grooves, lubricant screw, and lubricant receptacle. Acceptable products are:
 1. Neo Valves #1AS40114
 2. Newman Hattersley #171M
 3. KITZ 150 SCTAM-FS (flanged, 150 class, ball valve, 1/2-inch to 10 inches) CGA 3.16

2.04 NATURAL GAS CONVENIENCE OUTLET:

- A. Neo Valves Model 3/375 quick-connect type outlets with interlocking safety cam to prevent release of the appliance connector until the valve is off, integral thermal protection to prevent gas flow if the outlet is exposed to temperatures exceeding 200 degrees F, and a wall enclosure box.

2.05 NATURAL GAS PRESSURE REDUCING VALVE:

- A. Fisher (an Emerson Company) 1 inch x 1 inch Type S102C direct operating natural gas pressure reducing regulator with a cast iron body, 1 inch NPT connections, 9/16-inch orifice, and internal relief.

2.06 PRESSURE REDUCING REGULATORS:

- A. Provide Fisher pressure reducing regulators as presented in Schedule 23 11 23-1. Also provide pressure reducing regulators to suit the building load complete with relief.

2.07 GAS EQUIPMENT CONNECTORS:

- A. All gas equipment connectors shall be AGA-approved.
 - 1. Flexible Connectors: ANSI Z21.45 or ANSI Z21.24 and approved for use in Utah, maximum length of the connector shall not exceed 36 inches.
 - 2. Quick Disconnect Couplings: ANSI Z21.41.
 - 3. Semi-Rigid Tubing and Fittings: ANSI Z21.69.

2.08 METERS:

- A. ANSI B109.2 pipe mounted, diaphragm or bellow style, enamel coated steel case. Provide combined register totalizer reading in cubic feet, water escape hole in housing, and means for sealing against tampering. Meters shall have corrosion resistant factory painted finish.

2.09 REGULATORS:

- A. AGA-approved, self-contained with spring-loaded diaphragm pressure regulating valve and atmospheric vent, corrosion resistant construction, pressure operating range as required for the pressure reduction indicated, volume capacity not less than indicated, threaded ends for sizes 2-inch and smaller, otherwise flanged. Regulators shall have corrosion resistant factory painted finish. Regulators shall be designed for the gas used.

2.10 PRESSURE GAUGES:

- A. ASME B 40.1.

2.11 PIPE HANGERS AND SUPPORTS:

- A. Provide MSS SP-58, Type 1, 7, and 41 hangers with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel with drilled hole on centerline and double nut and flat washer. Attach to wood framed structures using wood screws designed for use with threaded rod adapters, or through-bolted with double nut and flat washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Hangers, supports, rods and fasteners shall be hot-dipped galvanized steel. Hangers and supports in contact with bare copper tubing shall be PVC coated. Hangers and supports shall be Series 300 stainless steel. Rods and fasteners shall be Series 300 stainless steel.

2.12 SUPPLEMENTARY STEEL AND CHANNELS:

- A. Unless otherwise indicated on the Structural Drawings, provide all supplementary steel and factory fabricated channels required for proper installation, mounting and support of all equipment and systems provided under this Section.
- B. Supporting channels and supplementary steel shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for the specific loading on the system installed herein.
- C. All supplementary steel shall be ASTM A36 factory-formed standard mill finished structural shapes, and shall be steel, field painted after fabrication. Channels shall be painted steel.

2.13 PIPE SLEEVES:

- A. Sleeves in Masonry and Concrete Walls, Floors, Ceilings, and Flat Roofs: Schedule 40 hot dipped galvanized, standard weight ductile-iron or cast-iron pipe sleeves. Sleeves available from the manufacturer of mechanically adjustable segmented elastomeric seals shall be permitted subject to acceptance by the Engineer. Provide minimum 2 inch high waterstop for sleeves in exterior walls and floors.
- B. Sleeves in Non-Masonry or Non-Concrete Walls, Floors, and Roofs: Hot-dip galvanized steel sheet, 26 gage minimum thickness.
- C. Mechanically Adjustable Segmented Elastomeric Seals: Seals shall have low durometer EPDM seal elements and series 300 stainless steel hardware.

2.14 PIPE ESCUTCHEONS:

- A. General: Provide pipe escutcheons at all pipe penetrations where penetration is exposed to view as specified herein with inside diameter closely fitting pipe outside diameter. Select outside diameter of escutcheon to completely cover pipe penetration hole in

floors, wall, or ceilings; and pipe sleeve extension, if any. Escutcheons shall be held in place by internal spring tension or set screws.

- B. Provide pipe escutcheons in finished spaces. Pipe escutcheons shall be of stainless steel, anodized aluminum or chrome-plated brass, solid or split hinged.

2.15 ACCESS PANELS:

- A. Access panels shall give access to each valve in concealed spaces above non removable (hard) suspended ceilings, and to all other concealed parts of the system. Access panels shall be located where indicated on the Drawings and/or where otherwise require accessibility for the proper inspection, operation and maintenance of the system.
- B. Access panels shall be Milcor Type M, 16-inch by 16-inch minimum, as manufactured by Inryco, Inc. Door shall be constructed of 18 gage galvanized steel with frame constructed of 16 gage galvanized steel. Casing bead shall be galvanized steel. Hinge shall be continuous steel with stainless steel pin. Locks shall be flush-screwdriver operated, with metal cam. Galvanized steel sleeve shall be welded to panel for access to cam lock control. Prime coat shall be factory applied rust-inhibitive light grey paint.

PART 3 - EXECUTION

3.01 NATURAL GAS SERVICE:

- A. Make all required arrangements with Dominion Energy on behalf of the Owner for installation of natural gas service piping with gas pressure regulator and meter assembly where shown.
- B. Arrange for permits, inspections, and tests, in accordance with applicable State and local codes, at the contractor's expense.
- C. Verify all measurements at the Project Site.
- D. Avoid interferences with other trades.

3.02 NATURAL GAS PIPING INSTALLATION REQUIREMENTS:

- A. Installation, workmanship, inspection, and testing shall be in accordance with the specified Fuel Gas Code with the additions specified herein. Install natural gas piping upstream of meter/regulators or upstream of building connections in accordance with ASME B31.8. Install piping straight and true to bear evenly on hangers and supports. Keep the interior and ends of new piping and existing piping affected by the Work thoroughly cleaned of water and foreign matter. Keep piping systems clean during installation by means of plugs or other accepted methods. When work is not in progress, securely close open ends of piping to prevent entry of water and foreign matter. Inspect piping before placing into position.

- B. Natural Gas Piping shall not be permitted in Electrical Rooms and stairwells.
- C. Piping and other apparatus shall not be installed in such a manner so as to interfere with the full swing of doors, movement of personnel and equipment, and access to other equipment.
- D. Make provisions for pipe expansion and contraction with suitable anchors and offsets, expansion joints, or expansion loops. Make provisions in buried piping for differential settlement. Install piping to allow freedom of movement in all planes without imposing undue stress on any section of the main piping, branch piping, equipment and structure.
- E. Piping: Cut pipe to actual dimensions and assemble to prevent residual stress. Provide supply connections entering the building as indicated. Within buildings, run piping parallel to structure lines and conceal in finished spaces. Fittings installed in concealed locations shall be limited to the following types: threaded elbows, tees, and couplings, brazed fittings, welded fittings, and fittings listed to ANSI LC-1 or ANSI LC-4. Terminate each vertical supply pipe to burner or appliance with tee, nipple and cap to form a sediment trap. To supply multiple items of gas-burning equipment, provide manifold with inlet connections at both ends.

1. Cleanliness:

- a. Clean inside of pipe and fittings before installation. Blow lines clear using 80 to 100 psig clean dry compressed air. Rap steel lines sharply along entire pipe length before blowing clear.

2. Buried Polyethylene (PE) Piping:

- a. Provide totally PE piping. Buried piping shall not be permitted under any building and/or structure. Terminate buried piping not more than 6 inches above grade. Prior to installation, obtain printed instructions and technical assistance in proper installation techniques from pipe manufacturer. When joining new PE pipe to existing pipe line, ascertain when procedural changes in the fusion process is necessary to attain optimum bonding.

- (1) PE Piping: Provide fusion-welded joints except where transitions have been specified. Use electrically heated tools, thermostatically controlled and equipped with temperature indication. (Where connection must be made to existing plastic pipe, Contractor shall be responsible for determination of compatibility of materials and procedural changes in fusion process necessary to attain maximum integrity of bond.)
- (2) Laying PE Pipe: Minimum cover over pipe shall be 30 inches below finish grade or 36 inches below any drainage ditches or deeper when indicated. Minimum cover for services lines to any building or structure shall be 18 inches. Maintain 6 inches of clearance between natural gas piping and any other utility or structure. If minimum

clearance cannot be maintained, the natural gas pipe shall be protected with a casing pipe. Service lines shall be sloped to drain back to the distribution pipe. Lay in accordance with manufacturer's printed instructions.

- (3) Buried gas piping shall not penetrate building foundation walls at any point below grade per FGC of Utah Section 404.6. Gas piping shall enter buildings or structures at a point above grade and the annular space between the pipe and the wall shall be sealed.
- b. Excavating and Backfilling: Pipe bedding and compacted backfill shall be provided under this Section of the Specifications in accordance with the requirements of Section 31 22 00. Pipe bedding shall be 6 inches deep. Compacted backfill shall be to a point 12 inches above the crown of buried pipe. Bedding and compacted backfill shall be non-corrosive material such as cleaned washed sand, and contain no stones, metal, rubbish of any kind, frozen material, organic matter, or any other material capable of damaging piping or coating, and/or of settling. Gas lines shall be buried in the trenches separate from all other utilities including other gas lines. Trenches shall be wide enough to permit at least 6 inches spacing between the sides and floor of the trench. Make provisions in buried piping for differential settlement, e.g. snaking the piping in the trench before backfilling. Coordinate provision of utility warning identification tape with backfill operation. Bury utility warning and identification tape with printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.
- c. PE Pipe Installation Guidelines:
- (1) Acceptable plastic PE pipe is manufactured according to standard ASTM D2513 and is marked with "ASTM D2513". The PE type designations recommended are PE 2406, and PE 3408.
 - (2) PE plastic pipe is unsuitable for aboveground installation. Plastic pipe must be buried or inserted.
 - (3) Make each joint in accordance with written procedures that have been proven by test to produce strong gas-tight joints. PE plastic pipe joining procedures can be obtained from qualified manufacturers. Do not purchase a product if the manufacturer or supplier does not certify it for qualified joining procedures.
 - (4) All pipe joining procedures must be conducted by qualified person following the written joining procedures for each type of pipe and fitting used. No person shall make a plastic pipe joint unless that person has been qualified under the applicable joining procedure by making a specimen joint that passes inspection and test. The specimen

joint must be visually examined during and after joining and found to have the same appearance as a joint or photograph of a joint that is acceptable under the procedure. In the case of heat fusion, the specimen must be cut into at least three longitudinal straps, each of which is:

- (a) Visually examined and found not to contain voids or discontinuities on the cut surfaces of the joint area;
 - (b) Deformed by bending, torque, or impact, and if failure occurs, it must not initiate in the joint area.
- (5) Install properly designed valves in a manner that will protect the plastic material. Protect the pipe from excessive twisting, shearing, or cutting loads when the valve is operated. Protect from any secondary stresses that might be induced through the valve or its enclosure.
 - (6) Prevent pullout and joint separation. Plastic pipe must be installed in such a manner that expansion and contraction of the pipe will not cause pullout or separation of the joint.
 - (7) When inserting plastic pipe in a metal pipe, make allowance for thermal expansion and contraction. Make an allowance at lateral and end connections on inserted plastic pipes, particularly those over 50 feet in length. End connections must be designed to prevent pullout caused by thermal contraction. Fittings must be able to restrain a force equal to or greater than the strength of the pipe. To minimize the stress caused by thermal contraction, pipes inserted in the summer should be allowed to cool to ground temperature before tie-ins are made. Inserted pipes, especially those pulled in, should be relaxed, mechanically compressed, or cooled to avoid initial tensile stress. Operators unfamiliar with proper insertion techniques must have a qualified person develop the procedures.
 - (8) Repair or replace imperfections or damages before placing the pipe in service.
 - (9) Install all plastic mains and service lines below ground level. Where the pipe is installed in a vault or other below-grade enclosure, it must be completely encased in gas-tight metal pipe with fittings that are protected from corrosion. Plastic pipe installation must minimize shear and other stresses. Plastic mains and service lines that are not encased must have an electrically conductive wire or other means of locating the pipe. Plastic lines must not be used to support external loads.
 - (10) A yellow insulated copper tracer wire shall be installed adjacent to underground PE pipe. Access shall be provided to the tracer wire of the tracer wire shall terminate above ground at each end of the PE

piping. The tracer wire size shall not be less than 12 AWG solid copper and the insulation type shall be 30 to 45 mils polyethylene suitable for direct burial, Southwire Tracer Wire, or approved equal.

- (11) Ensure that plastic PE pipe is continually supported along its entire length by properly tamped and compacted soil. To prevent any shear or other stress concentrations use external stiffeners at connections to main, valves, meter risers, and other places where compression fittings might be used.
- (12) In laying of plastic PE pipe, ensure adequate slack (snaking) in the pipe to prevent pullout due to thermal contraction.
- (13) Suitable bedding (sand) and backfill must be provided. Ensure backfill with material that does not contain any large or sharp rocks, broken glass, or other objects that could cut or puncture the pipe.
- (14) Take special care to prevent coal tar type coatings or petroleum base tape from contacting the plastic pipe. It can cause plastic pipe to deteriorate.
- (15) Static electricity can ignite a flammable gas-air atmosphere. When working with plastic pipe of any kind where there is (or there may be) the possibility of a flammable gas-air atmosphere, take the following precautions:
 - (a) Use a grounded wet tape conductor wound around, or laid in contact with, the entire section of the exposed piping.
 - (b) If gas is already present, wet the pipe starting from the ground end with a very dilute water and detergent solution. Apply tape immediately and leave it in place.
 - (c) Wet the tape occasionally with water. Where temperatures are below freezing (32 degrees F) add glycol to the water to maintain tape flexibility. Ground the tape with a metal pin driven into the ground.
 - (d) Do not vent gas using an ungrounded plastic pipe or tubing. Even with grounded metal piping, venting gas with high scale or dust content could generate an electric charge in the gas resulting in an arc from the dusty gas cloud back to the pipe which could ignite the gas. Vent gas only at a downwind location remote from people or flammable material.
 - i. Dissipating the static charge buildup with wet rags, a bare copper wire, or other similar techniques may not be as effective as the above procedure. In all cases, use

appropriate safety equipment such as flame resistant and static free clothing, breathing apparatus, etc.

- (16) In transition area where the plastic pipe is connected to a fitting, valve, or riser, the use of protective sleeves may be needed to distribute excessive stresses, along with attention to adequate backfill and support.

3. Aboveground Steel Piping:

- a. Determine and establish measurements for piping at job site and accurately cut pipe lengths accordingly. For 2-inch diameter and smaller, use threaded or socket-welded joints. For 2 1/2-inch diameter and larger, use flanged or butt-welded joints.
 - (1) Threaded Joints: Where possible use pipe with factory-cut threads, otherwise cut pipe ends square, remove fins and burrs and cut taper pipe threads in accordance with ASME B1.20.1. Provide threads smooth, clean and full-cut. Anti-seize jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread paste, pipe cement and oil, or PTFE powder and oil. PTFE tape is also acceptable. Apply jointing compound to male threads only. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Use unions for connections to valves, meters, and regulators for which a mean of disconnection is not otherwise provided.
 - (2) Welded Joints: Weld by the shielded metal-arc process, using covered electrodes and in accordance with procedures established and qualified in accordance with ASME B31.8.
 - (3) Flanged Joints: Use flanged joints for connecting welded joint pipe and fittings to valves, meters, and regulators to provide for disconnection. Install joints so that flange faces bear uniformly on gaskets. Engage bolts so that there is complete threading through the nuts and tighten so that bolts are uniformly stressed and equally torqued.
 - (4) Pipe Size Changes: Use reducing fittings for changes in pipe size. Size changes made with bushings will not be accepted.

4. Connections to Existing Pipeline:

- a. Dominion Energy will make the connection to the existing pipeline.

5. Wrapping:

- a. Where connection to existing steel line is made underground, tape wrap new steel transition fittings and exposed existing pipe having damaged coating. Clean pipe to bare metal. Initially stretch first layer of tape to conform to the surface while spirally half-lapping. Apply a second layer, half-lapped and spiraled as the first layer, but with spirals perpendicular to first wrapping. Use 10 mil minimum thick polyethylene tape. In lieu of tape wrap, heat shrinkable 10 mil minimum thick polyethylene sleeve may be used.

F. Valves:

1. Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide support for valves to resist operating torque applied to PE pipes.
2. Stop Valve and Shutoff Valve:
 - a. Provide stop valve on service branch at connection to main and shut-off valve on riser outside of each building. Provide shut-off valve at connection to each gas utilization appliance and where otherwise indicated.

G. Gas Regulators:

1. Provide plug cock shutoff valve on both sides of each regulator. Install regulators outside of buildings and 18 inches aboveground on riser., unless specifically detailed otherwise. Install gas meter in conjunction with pressure regulator. On outlet side of regulator or meter, provide a union and a 3/8-inch gage tap with plug.

H. Pipe Hangers and Supports:

1. Selection, application, and installation of piping hangers and supports shall conform with MSS SP-58, unless otherwise indicated.
2. Furnish and install safe and substantial means of support for all parts of the piping system. Attach all pipes securely to the structure in correct alignment and pitch, to prevent vibration and to effectively care for expansion and contraction.
3. All piping shall be hung to true alignment, using appropriate hanger arrangements. Wire and strap hangers shall not be permitted. Hangers shall be located so that piping and hangers will be clear of other piping, hangers, conduits, lighting fixtures, equipment, ceiling suspension systems, ductwork, and other obstructions.
4. Supplementary steel and channels shall be firmly connected to the building construction in a manner accepted by the Engineer, or as otherwise shown on the Drawings. Equipment and piping shall not be supported from metal decking or plaster ceilings.

5. Rod sizes, MSS SP-58.
6. Maximum Spacing Between Supports:
 - a. Support piping within one foot on either side of regulators, flanged valves, and changes in direction. Support within 2 feet of wall penetrations.
 - b. Vertical Piping: Support piping at each floor, but at not more than 10 foot intervals, with pipe riser clamps or offset pipe clamps. Support within 2 feet of floor and roof penetrations.
 - c. Horizontal Piping: Locate supports within one foot of each change of direction. Support straight runs of steel piping and copper tubing as follows:

Maximum Spacing Feet									
Nominal Pipe Size inches	One and under	1-1/4	1-1/2	2	2-1/2	3	4	5	6
Steel Pipe (Vapor)	8	9	12	13	14	15	17	19	21
Copper Tube (Vapor)	6	9	10	11	13	14	16	18	20

I. Seismic Bracing Requirements

1. Piping and equipment shall be supported and braced to resist seismic loads where required by the specified Building Code. Provide seismic restraints in accordance with SMACNA Seismic Restraint Manual unless otherwise required by the specified building code.

J. Pipe Through-Penetrations

1. Furnish pipe sleeves where pipe passes through walls, floors, ceilings, roofs, and partitions. Sleeves will be installed, secured in proper position and location during construction by the trade whose element will be penetrated. Such trades include concrete, masonry, steel siding in the case of a steel building, and dry wall in the case of framed construction. Core drilled holes in masonry and concrete may be provided by this Section in lieu of pipe sleeves, however cored drilled holes in masonry shall have cavities completely grouted. Furnish sleeves of sufficient length to pass through entire thickness of walls, floors, ceilings, roofs, and partitions.
2. Pipe Penetrations Through Building Interior Construction: Provide not less than 1/4-inch one inch space between exterior of piping and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. For non-fire rated assemblies, seal at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass or silicone. Seal both

ends of penetrations through fire rated assemblies to maintain fire resistive integrity with UL listed fill, void, or cavity material.

3. Pipe Penetrations Through Building Exterior Construction: Provide a mechanically adjustable segmented elastomeric seal, with sleeve sized as recommended by seal manufacturer. Seals shall have EPDM seal elements and Series 300 stainless steel hardware.
4. Extend sleeves in floor slabs 2 inches above the finished floor.
5. Seismic-braced Pipe:
 - a. Proper clearances between penetrating gas system piping and any barrier shall be provided. The penetration holes shall be sized such that the hole diameter is 2 inches larger for pipe diameters 1-inch nominal to 3-inch nominal, and 4 inches larger for 4 inch and larger nominal diameter pipe.
 - b. All open space around seismically braced through-penetrations shall be protected by a Listed, flexible through-penetration seal system.

K. Final Connections: Make final connections to equipment and appliances using rigid pipe and fittings, except for the following:

1. Domestic Water Heaters:
 - a. Connect with semi-rigid tubing and fittings.
2. Equipment:
 - a. Install flexible connectors. Connectors shall be long enough to permit movement of equipment for cleaning and to afford access to coupling.
3. Generators and HVAC equipment.
4. Install flexible connectors. Connectors shall have sufficient slack to avoid all stresses associated with generator vibration.

L. Provide full pipe diameter 6-inch long drip pockets at the bottom of all vertical risers, at all piping low points, and wherever else shown and/or required.

M. Identify all natural gas piping with two coats of safety yellow enamel applied over primer, and SMS Ltd. coil type vinyl identification makers with arrows.

3.03 INSTALLATION OF SHUT-OFF VALVES:

- A. Provide TSSA approved ball type or lubricated plug type shut-off valves to isolate equipment, and wherever else shown.
- B. Ensure that valves are located for easy accessibility and maintenance.

3.04 INSTALLATION OF NATURAL GAS CONVENIENCE OUTLETS:

- A. Provide natural gas convenience outlets and wall mount where shown.
- B. Provide a shut-off valve in connecting piping, confirm exact location prior to roughing-in, and ensure that the outlet is rigidly secured in place.

3.05 FIELD QUALITY CONTROL:

- A. Prior to initial operation, inspect systems for compliance with Drawings, Specifications and accepted submittals. As part of inspection, perform inspections, tests and purging in compliance with the specified requirements. Have systems accepted by the Engineer before concealing.
- B. Test Procedures and Reports:
 - 1. Prepare and submit procedures, material, and equipment for all specified tests to the Engineer for acceptance prior to the planned tests. Material and equipment used in testing shall be subject to inspection by the Engineer.
 - 2. Provide all material and labor required for testing. Instruments, test equipment, and test personnel required to properly conduct all tests shall be provided. Provide water, fuel, electricity. The Owner will furnish water, fuel, and electricity for the tests.
 - 3. Repair defects disclosed by tests or, if required by the Engineer, replace defective work with new work without additional cost. If any deficiencies are revealed during test, such deficiencies shall be corrected and the tests reconducted at no additional cost.
 - 4. Test reports shall include accepted test procedures, test results, deficiencies identified, and recommended corrective actions. Provide a complete explanation including supporting documentation detailing the design deficiencies. State that no deficiencies are evident if that is the case. When tests have been completed and corrections made, submit signed and dated test reports.
- C. Metal Welding Inspection:
 - 1. Inspect for compliance with the specified Fuel Gas Code except natural gas piping upstream of meter/regulators shall be inspected for compliance with ASME B31.8. Replace, repair and then re-inspect defective welds.
- D. PE Fusion Welding Inspection:
 - 1. Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect 100 percent of all joints and reinspect all corrections. Arrange with the pipe

manufacturer's representative in the presence of the Engineer to make first time inspection.

E. Piping Pressure Tests:

1. Test system gas tight in accordance with the specified Fuel Gas Code with the additions specified herein. For natural gas piping upstream of meter/regulators, test system gas tight in accordance with ASME B31.8. Use test pressure of 1-1/2 times maximum working pressure, but in no case less than 50 psig. Do not test until every joint has set and cool at least 8 hours at temperatures above 50 degrees F. Use clean dry air or inert gas, such as nitrogen or carbon dioxide, for testing. Systems which may be contaminated by gas shall first be purged as specified. Make tests on entire system or on sections that can be isolated by valves. After pressurization, isolate entire piping system from sources of air during test period. Maintain test pressure for at least 8 hours between times of first and last reading of pressure and temperature. Take first reading at least one hour after test pressure has been applied. Do not take test readings during rapid weather changes.
 - a. For buried piping, conduct testing before backfilling; however, place sufficient backfill material between fittings to hold pipe in place during tests. Provide gas temperature same as actual trench conditions.
2. There shall be no reduction in the applied test pressure other than that due to a change in ambient temperature. Allow for ambient temperature change in accordance with the relationship $PF + 14.7 = (P_1 + 14.7) (T_2 + 460) / T_1 + 460$, in which "T" and "P" represent Fahrenheit temperature and gage pressure, respectively, subscripts "1" and "2" denote initial and final readings, and "PF" is the calculated final pressure. If "PF" exceeds the measured final pressure (final gage reading) by 1/2 psi or more, isolate sections of the piping system, retest each section individually, and apply a solution of warm soapy water to joints of each section for which a reduction in pressure occurs after allowing for ambient temperature change. In performing tests, use a test gage calibrated in one psi increments and readable to 1/2 psi.
3. Correct defects in Work and repeat test until no reduction in pressure occurs.

- F. System Purging: After completing pressure tests, and before testing a gas contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clean completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures shall conform to the specified Fuel Gas Code and ASME B31.8, whichever is more stringent.

CAUTION

Failure to purge may result in explosion within line when air-to-gas is at correct mixture.

- G. Functional Testing: All equipment, control devices and signaling devices shall be tested individually to demonstrate proper operation. Test all control panel functions to demonstrate proper operation. Test all control system functions to demonstrate proper operation in accordance with the specified control sequences. Monitoring signals to the facility Supervisory Control and Data Acquisition (SCADA) system shall be verified.

3.06 MANUFACTURER'S INSTRUCTIONS AND SERVICES:

- A. Obtain instructions from the manufacturer for the proper method of installation and connection of the equipment that is to be installed. Obtain all information that is necessary to facilitate the Work and to complete the project.
- B. Provide manufacturer's services in accordance with Section 01 78 25. Services shall be provided for the satisfactory completion of installation, start-up, testing and training for those equipment and systems described herein below.
 - 1. Gas booster system.
- C. Upon completion of all Work, furnish, in duplicate, certificates of inspection from equipment manufacturers stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be in satisfactory operating condition.

3.07 PAINTING:

- A. Field painting of above ground gas piping shall be provided under this Section in accordance with Section 09 96 00.
- B. Field touch-up all damaged factory or shop applied coatings for material and equipment furnished under this Section in accordance with the manufacturer's recommendation.
- C. Provide shop painting system, under this Section, of the following. Color of finish coat shall be yellow.
 - 1. Hangers and supports in exposed locations.
 - 2. Pipe, fittings, and valves in exposed locations.
- D. Do not apply paint until piping tests have been completed and accepted by the Engineer.

3.08 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

3.09 SCHEDULES:

Schedule 23 11 23-1			
Building	Projected Gas Load¹	Regulator (Fisher)	Relief (Fisher)
	SCFH	Model	Model
WTP	3,300	S202H 2-inch body 1-inch orifice	289H 1-inch
Generators	14,930	EZR ²	OSX
¹ Confirm gas load for each building prior to ordering the valves.			
² Confirm minimum and maximum pressure with Dominion Energy.			

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Provide hydronic piping as indicated and in compliance with Contract Documents.

1. Copper tube and fittings
2. Steel pipe and fittings
3. Joining Materials
4. Dielectric fittings

1.02 REFERENCES:

A. American Society of Mechanical Engineers (ASME):

1. Boiler and Pressure Vessel Code

B. American Society of Sanitary Engineering (ASSE):

1. 1079: Performance Requirements for Dielectric Pipe Unions

C. ASTM International (ASTM):

1. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2. A106: Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
3. A234: Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
4. A536: Standard Specification for Ductile Iron Castings

D. American Welding Society (AWS):

1. D10.12: Recommended Practices and Procedures for Welding Low Carbon Steel Pipe

E. International Association of Plumbing and Mechanical Officials (IAPMO):

1. PS 66: Dielectric Fittings

F. Manufacturers' Standardization Society (MSS):

1. SP-58: Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application and Installation

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Product Data: For each type of the following:

1. Pipe
2. Fittings
3. Joining materials

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

D. Qualification Data: For Installer.

E. Welding certificates.

1.04 SUSTAINABLE DESIGN:

A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Installer Qualifications:
 - 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
- C. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."
- D. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 - 1. Hot-Water/Glycol Heating Piping: 150 psig at 180 degrees F
 - 2. Chilled-Water/Glycol Piping: 150 psig from 0 to 150 degrees F
 - 3. Makeup-Water Piping: 150 psig 73 degrees F
 - 4. Condensate-Drain Piping: 100 degrees F
 - 5. Air-Vent Piping: 180 degrees F
 - 6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.02 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
 - 1. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
 - 2. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.
- E. Copper or Bronze Pressure-Seal Fittings:
 - 1. Housing: Copper.
 - 2. O-Rings and Pipe Stops: EPDM.
 - 3. Tools: Manufacturer's special tools.
 - 4. Minimum 200-psig working-pressure rating at 250 deg F.
- F. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
- G. Wrought-Copper Unions: ASME B16.22.

2.03 STEEL PIPE AND FITTINGS:

- A. Steel Pipe: Grooved Joint, ASTM A53, black steel , Grade B, with factory or site rolled groove.
- B. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers:
 - a. Victaulic
 - b. Gruvlock
 - c. Anvil
 - 2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47, Grade 32510 malleable iron; ASTM A53, Type F, E, or S, Grade B fabricated

steel; or ASTM A106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

3. Couplings: Ductile- or malleable-iron housing and EPDM gasket rated for -30 degrees F to 230 degrees F with polypropylene glycol of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.04 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

- a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
- b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

- G. Solvent Cements for CPVC Piping: ASTM F 493.

- H. Solvent Cements for PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.05 DIELECTRIC FITTINGS:

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Description:

- a. Standard: ASSE 1079
- b. Pressure Rating: 150 psig
- c. End Connections: Solder-joint copper alloy and threaded ferrous

C. Dielectric Flanges:

1. Description:

- a. Standard: ASSE 1079
- b. Factory-fabricated, bolted, companion-flange assembly
- c. Pressure Rating: 150 psig
- d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Description:

- a. Nonconducting materials for field assembly of companion flanges
- b. Pressure Rating: 150 psig
- c. Gasket: Neoprene or phenolic
- d. Bolt Sleeves: Phenolic or polyethylene
- e. Washers: Phenolic with steel backing washers

E. Dielectric Nipples:

1. Description:

- a. Standard: IAPMO PS 66
- b. Electroplated steel nipple, complying with ASTM F1545
- c. Pressure Rating: 300 psig at 225 degrees F
- d. End Connections: Male threaded or grooved
- e. Lining: Inert and noncorrosive, propylene

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS:

- A. Hot and Chilled-Water Piping, Aboveground, NPS 2-1/2 and larger shall be the following:
 - 1. Steel Pipe Schedule 40: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article
 - 2. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
- B. Hot and Chilled-Water Piping, Aboveground, NPS 2 and smaller shall be the following:
 - 1. Schedule 40 steel pipe; Class 150, malleable iron fittings; cast-iron fittings; flanges, and flange fittings; and threaded joints.
 - 2. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
- C. Make-up water piping, Aboveground shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed, or soldered, joints.
- D. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- E. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
 - 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.02 PIPING INSTALLATION:

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- C. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- D. Install piping to permit valve servicing.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- K. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- L. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- M. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- N. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- O. Install valves according to the following:
 - 1. Section 23 05 23.12
 - 2. Section 23 05 23.13
 - 3. Section 23 05 23.14
 - 4. Section 23 05 23.15
- P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install flanges in piping, 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- R. Install shutoff valve immediately upstream of each dielectric fitting.

- S. Comply with requirements in Section 23 05 53 for identifying piping.
 - T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17.
 - U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17.
 - V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18.
- 3.03 DIELECTRIC FITTING INSTALLATION:
- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- 3.04 INSTALLATION OF HANGERS AND SUPPORTS:
- A. Comply with requirements for seismic-restraint devices specified in Section 23 05 48.
 - B. Comply with requirements in Section 23 05 29 for hangers, supports, and anchor devices.
 - C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
 - D. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
 - E. Support horizontal piping within 12 inches of each fitting and coupling.

- F. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.05 PIPE JOINT CONSTRUCTION:

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- I. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

3.06 TERMINAL EQUIPMENT CONNECTIONS:

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 05 19.

3.07 CHEMICAL TREATMENT:

- A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- B. Fill systems that have antifreeze or glycol solutions with the following concentrations:
 - 1. Hot-Water Heating Piping: Minimum of 30 percent propylene glycol.
 - 2. Chilled-Water Piping: Minimum of 30 percent propylene glycol.

3.08 FIELD QUALITY CONTROL:

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, to specified values.
7. Verify lubrication of motors and bearings.

3.09 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 21 16

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:

- 1. Hydronic specialty valves.
 - 2. Air-control devices.
 - 3. Strainers.
 - 4. Connectors.

- B. Related Requirements:

- 1. Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
 - 2. Section 23 05 23.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
 - 3. Section 23 05 23.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
 - 4. Section 23 05 23.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
 - 5. Section 23 05 23.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
 - 6. Section 23 09 23.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.05 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.06 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.01 HYDRONIC SPECIALTY VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
 1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 2. Ball: Brass or stainless steel.
 3. Plug: Resin.
 4. Seat: PTFE.
 5. End Connections: Threaded or socket.
 6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 7. Handle Style: Lever, with memory stop to retain set position.

8. CWP Rating: Minimum 125 psig (860 kPa).
 9. Maximum Operating Temperature: 250 deg F (121 deg C).
- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 2. Ball: Brass or stainless steel.
 3. Stem Seals: EPDM O-rings.
 4. Disc: Glass and carbon-filled PTFE.
 5. Seat: PTFE.
 6. End Connections: Flanged or grooved.
 7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 8. Handle Style: Lever, with memory stop to retain set position.
 9. CWP Rating: Minimum 125 psig (860 kPa).
 10. Maximum Operating Temperature: 250 deg F (121 deg C).
- C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Body: Bronze or brass.
 2. Disc: Glass and carbon-filled PTFE.
 3. Seat: Brass.
 4. Stem Seals: EPDM O-rings.
 5. Diaphragm: EPT.
 6. Low inlet-pressure check valve.
 7. Inlet Strainer: Removable without system shutdown.
 8. Valve Seat and Stem: Noncorrosive.
 9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- D. Diaphragm-Operated Safety Valves: ASME labeled.

1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: Removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves:

1. Body: Brass or ferrous metal.
2. Flow Control Assembly, provide either of the following:
 - a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
 - b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig (14- to 550-kPa) differential pressure.
3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size: Same as pipe in which installed.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: 175 psig.
8. Maximum Operating Temperature: 250 deg F.

2.02 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Screwdriver or thumbscrew.
 4. Inlet Connection: NPS 1/2 (DN 15).
 5. Discharge Connection: NPS 1/8 (DN 6).
 6. CWP Rating: 150 psig (1035 kPa).
 7. Maximum Operating Temperature: 225 deg F (107 deg C).
- B. Automatic Air Vents:
1. Body: Bronze or cast iron.
 2. Internal Parts: Nonferrous.
 3. Operator: Noncorrosive metal float.
 4. Inlet Connection: NPS 1/2 (DN 15).
 5. Discharge Connection: NPS 1/4 (DN 8).
 6. CWP Rating: 150 psig (1035 kPa).
 7. Maximum Operating Temperature: 240 deg F (116 deg C).
- C. Bladder-Type ASME Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- D. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- E. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.

2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

2.03 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

2.04 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.

4. CWP Rating: 150 psig.
 5. Maximum Operating Temperature: 250 deg F.
- B. Spherical, Rubber, Flexible Connectors:
1. Body: Fiber-reinforced rubber body.
 2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 3. Performance: Capable of misalignment.
 4. CWP Rating: 150 psig.
 5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.01 VALVE APPLICATIONS

- A. Install shut off-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.02 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

- C. Install piping from boiler air outlet or air separator to expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- F. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - 1. Install tank fittings that are shipped loose.
 - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- G. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION

SECTION 23 21 23
HYDRONIC PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide hydronic pumps as indicated and in compliance with Contract Documents.
 - 1. Close-coupled end-suction centrifugal pumps

1.02 REFERENCES:

- A. American National Standards Institute (ANSI):
 - 1. B15.1: Safety Standard for Mechanical Power Transmission Apparatus
- B. American Society of Mechanical Engineers (ASME):
 - 1. B16.1: Pipe Flanges and Fittings
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code

1.03 SUBMITTALS:

- A. Submit shop drawings and product data in accordance with Section 01 33 00.
- B. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- C. Shop Drawings: For each pump.
 - 1. Show pump layout and connections.
 - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 3. Include diagrams for power, signal, and control wiring.
- D. For each device, equipment or appurtenance provide written certification in accordance with Specification 01 41 20.

E. Operation and Maintenance Data: For pumps to include in mechanical systems emergency, operation, and maintenance manuals.

F. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal for each pump.

1.04 SUSTAINABLE DESIGN:

A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

1.07 DELIVERY STORAGE AND HANDLING:

A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS:

A. Manufacturers:

1. Armstrong
2. Taco Comfort Solutions
3. Bell & Gossett
4. ITT

B. Description: Factory-assembled and tested, single stage, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Capacities and Characteristics:

1. Per Equipment Schedules in Drawings.

D. Pump Construction:

1. Casing: Radially split, cast iron, with drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connection
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Per manufacturer.

E. Motor: Single speed and rigidly mounted to pump casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13.
 - a. Enclosure: Totally enclosed, fan cooled.
 - b. Motor Bearings: Per manufacturer.
 - c. Unusual Service Conditions:
 - (1) Altitude: 4221 above sea level
 - d. Efficiency: Premium efficient

2.02 PUMP SPECIALTY FITTINGS:

A. Suction Diffuser:

1. Angle pattern
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting
3. Bronze startup and bronze or stainless-steel permanent strainers
4. Bronze or stainless-steel straightening vanes
5. Drain plug

6. Factory-fabricated support
 7. Manufacturers:
 - a. Armstrong
 - b. Taco Comfort Solutions
 - c. Bell & Gossett
 - d. ITT
- B. Triple-Duty Valve:
1. Angle or straight pattern
 2. 175-psig pressure rating, cast-iron body, pump-discharge fitting
 3. Drain plug and bronze-fitted shutoff, balancing, and check valve features
 4. Brass gage ports with integral check valve and orifice for flow measurement
 5. Manufacturers:
 - a. Armstrong
 - b. Taco Comfort Solutions
 - c. Bell & Gossett
 - d. ITT

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PUMP INSTALLATION:

- A. Comply with HI 1.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting:
 - 1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48.

3.03 ALIGNMENT:

- A. Perform alignment service.
- B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.04 CONNECTIONS:

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install triple-duty valve on discharge side of pumps.
- E. Install Y-type strainer and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

- G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- H. Install check valve and gate or ball valve on each condensate pump unit discharge.
- I. Ground equipment according to Section 26 05 26.
- J. Connect wiring according to Section 26 05 19.

3.05 STARTUP SERVICE:

- A. Perform Startup Service:
 - 1. Complete installation and startup checks according to manufacturer's written instructions
 - 2. Check piping connections for tightness
 - 3. Clean strainers on suction piping
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation
 - 6. Start motor
 - 7. Open discharge valve slowly

3.06 DEMONSTRATION:

- A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

3.07 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 23 00

REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 23 0719 - Refrigerant Piping Insulation

1.02 SUMMARY

- A. Section Includes:
 - 1. Refrigeration piping
 - 2. Refrigeration piping supports
 - 3. Connection materials

1.03 REFERENCES

- A. American National Standards Institute / American Welding Society
 - 1. ANSI / AWS A5.8-92, 'Standard Specification for Brazing Alloys'
- B. American Society for Testing and Materials
 - 1. ASTM A 36-00a, 'Standard Specification for Carbon Structural Steel'
 - 2. ASTM A 361-94, 'Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process for Roofing and Siding'
 - 3. ASTM B 280-99, 'Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service'

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Refrigeration piping and fittings.
 - 2. Piping supports and materials.

B. Shop Drawings - Show each individual equipment, refrigeration piping and piping support.

C. Quality Assurance / Control - Technician certificate for use of CFC and HCFC refrigerants

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.06 QUALITY ASSURANCE

A. Qualifications - Refrigerant piping shall be installed by a refrigeration contractor licensed by State and by technicians certified in use of CFC and HCFC refrigerants.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For equipment to include in emergency, operation and maintenance manuals.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Store piping in a clean dry location. Store on pipe racks off of the ground. Retain end caps on piping. Protect from damage and moisture.

1.09 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: 1 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 COMPONENTS

A. Refrigerant Piping

1. Meet requirements of ASTM B 280, hard drawn straight lengths. Soft copper tubing not permitted.

2. Do not use pre-charged refrigerant lines.

B. Refrigerant Fittings

1. Wrought copper with long radius elbows.

2. Approved Manufacturers -

- a. Mueller Streamline
 - b. Nibco Inc
 - c. Grinnell
 - d. Elkhart
 - C. Suction Line Traps
 - 1. Manufactured standard one-piece traps.
 - 2. Approved Manufacturers
 - a. Mueller Streamline
 - b. Nibco Inc
 - c. Grinnell
 - d. Elkhart
 - D. Connection Material
 - 1. Brazing Rods in accordance with ANSI / AWS A5.8 -
 - a. Copper to Copper Connections -
 - (1) Classification BCuP-4 Copper Phosphorus (6 percent silver).
 - (2) Classification BCuP-5 Copper Phosphorus (15 percent silver).
 - b. Copper to Brass or Copper to Steel Connections - Classification BAg-5 Silver (45 percent silver).
 - c. Do not use rods containing Cadmium.
 - 2. Flux -
 - a. Approved Products -
 - (1) Stay-Silv White Brazing Flux by J W Harris
 - (2) High quality silver solder flux by Handy & Harmon
- 2.02 MATERIALS

A. Refrigerant Piping Supports

- 1. Base, Angles, And Uprights - Steel meeting requirements of ASTM A 36.

2. Securing Channels -
 - a. At Free-Standing Pipe Support -
 - (1) Acceptable Products -
 - (a) P-1000 channels by Unistrut
 - (b) HS-158-12 channels by Hilti
 - (c) Equal as approved by Architect prior to installation. See Section 01600.
 - b. At Wall Support -
 - (1) Acceptable Products -
 - (a) P-3300 channels by Unistrut
 - (b) HS-1316-12 channels by Hilti
 - (c) Equal as approved by Architect prior to installation. See Section 01600.
 - c. At Suspended Support -
 - (1) Acceptable Products -
 - (a) P-1001 channels by Unistrut
 - (b) MS-41 channels by Hilti
 - (c) Equal as approved by Architect prior to installation. See Section 01600.
3. Angle Fittings -
 - a. Acceptable Products -
 - (1) P-2626 90-degree angle by Unistrut
 - (2) MW2 angle by Hilti
 - (3) Equal as approved by Architect prior to installation. See Section 01600.
4. Pipe Clamps -
 - a. Acceptable Manufacturers -

- (1) Hydra-Zorb
 - (2) ZSI Cush-A-Clamp
 - (3) Hilti Cush-A-Clamp
 - (4) Equal as approved by Architect prior to installation. See Section 01600.
5. Protective Cover - 18 ga steel, hot-dipped galvanized to meet requirements of ASTM A 361, 1.25 oz/sq ft.

2.03 MANUFACTURERS

- A. Alco Controls Div.
- B. Cush-A-Clamp by ZSI Manufacturing.
- C. Elkhart Products Corp.
- D. Grinnell Corp, Exeter.
- E. J W Harris Co Inc.
- F. Henry Valve Co.
- G. Hilti Inc, Tulsa.
- H. Hydra-Zorb Co.
- I. Mueller Steam Specialty.
- J. Nibco Inc.
- K. Packless Industries.
- L. Parker Hannefin Corp.
- M. Sporlan Valve Co.
- N. Unistrut Corp.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refrigerant Lines
 - 1. Install as high in upper mechanical areas as possible. Do not install underground or in tunnels.

2. Slope suction lines down toward compressor one inch/10 feet. Locate traps at vertical rises against flow in suction lines.

B. Connections

1. Refrigeration system connections shall be copper-to-copper type properly cleaned and brazed with specified rods. Use flux only where necessary. No soft solder (tin, lead, antimony) connections will be allowed in system.
2. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.

C. Refrigerant Supports

1. Support Spacing -
 - a. Piping 1-1/4 inch And Larger - 8 feet on center maximum.
 - b. Piping 1-1/8 inch And Smaller - 6 feet on center maximum.
 - c. Support each elbow.
2. Isolate pipe from supports and clamps with Hydrozorb or Cush-A-Clamp systems.
3. Run protective cover continuous from condensing units to risers or penetrations at building wall.

3.02 FIELD QUALITY CONTROL

- A. Make evacuation and leak tests in presence of Architect's Engineer after completing refrigeration piping systems. Positive pressure test will not suffice for procedure outlined below.
1. Draw vacuum on each entire system with two stage vacuum pump. Draw vacuum to 300 microns using micron vacuum gauge capable of reading from atmosphere to 10 microns. Do not use cooling compressor to evacuate system nor operate it while system is under high vacuum.
 2. Break vacuum with nitrogen and re-establish vacuum test. Vacuum shall hold for 30 minutes at 300 microns without vacuum pump running.
 3. Conduct tests at 70 deg F ambient temperature minimum.
 4. Do not run systems until above tests have been made and systems started up as specified. Inform Owner's Representative of status of systems at time of final inspection and schedule start-up and testing if prevented by outdoor conditions before this time.

5. After testing, fully charge system with refrigerant and conduct test with Halide Leak Detector.
 6. Recover all refrigerant in accordance with applicable codes. Do not allow any refrigerant to escape to atmosphere.
- B. If it's observed that refrigerant lines are being or have been brazed without proper circulation of nitrogen through lines, all refrigerant lines installed up to that point in time shall be removed and replaced at no additional cost to Owner.

END OF SECTION

SECTION 23 25 13

WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide water treatment for closed-loop hydronic systems as indicated and in compliance with Contract Documents.

- 1. Manual chemical-feed equipment
- 2. Chemicals

1.02 REFERENCES:

- A. ASTM International (ASTM):

- 1. A269: Standard Specification for Seamless and Welded Austentic Stainless Steel Tubing for General Service
- 2. D3370: Standard Practices for Sampling Water from Flowing Process Streams

- B. American Water Works Association (AWWA):

- 1. C700: Cold Water Meters - Displacement Type, Bronze Main Case
- 2. C701: Cold Water Meters - Turbine Type, for Customer Service

- C. National Fire Protection Association (NFPA):

- 1. 70: National Electrical Code

1.03 SUBMITTALS:

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

- 1. Bypass feeders
- 2. Injection pumps
- 3. Chemical material safety data sheets
- 4. Inhibited propylene glycol

- B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to hydronic systems.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.
- C. Seismic Qualification Certificates: For components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

- B. Sufficient chemical and consumable material shall be provided to maintain the system for one year after final commissioning and owner acceptance.
 - C. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- 2.02 MANUAL CHEMICAL-FEED EQUIPMENT:
- A. Bypass Feeders: Provide steel feeders with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Provide quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
 - 1. Capacity: 5 gallons
 - 2. Minimum Working Pressure: 125 psig
- 2.03 INHIBITED PROPYLENE GLYCOL:
- A. Inhibited Propylene Glycol:
 - 1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon steel, brass, copper, stainless steel, and cast-iron piping and fittings.
 - 2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
 - 3. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.
 - 4. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to minus 20 degrees F. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
 - 5. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that re-

quire servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 23 05 48 for seismic restraints.
- C. Bypass Feeders: Install in closed hydronic systems, including glycol heating, and glycol cooling, and equip with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps unless indicated otherwise on Drawings.
 - 2. Install water meter in makeup-water supply.
 - 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 - 5. Install a swing check on the inlet after the isolation valve.
- D. Install automatic fluid make-up equipment for glycol water system, and include the following:
 - 1. Chemical solution tanks
 - 2. Chemical solution injection pumps
 - 3. Water meter in makeup supply to system
 - 4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure

3.02 PIPING CONNECTIONS:

- A. Piping installation requirement are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 23 21 13.
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 23 05 23.12, Section 23 05 23.13, and Section 23 05 23.15.

- E. Comply with requirements in Division 22 for backflow preventers required in makeup-water connections to potable-water systems.

3.03 ELECTRICAL CONNECTIONS:

- A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- B. Ground equipment in accordance with Section 26 05 26.

3.04 FIELD QUALITY CONTROL:

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.05 DEMONSTRATION:

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

3.06 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Provide metal ducts as indicated and in compliance with Contract Documents.

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

1.02 REFERENCES:

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. 62.1: Ventilation for Acceptable Indoor Air Quality
2. 90.1: Energy Standard For Buildings Except Low-Rise Residential Buildings

B. ASTM International (ASTM):

1. A36: Standard Specification for Carbon Structural Steel
2. A480: Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
3. A492: Standard Specification for Stainless Steel Rope Wire
4. A603: Standard Specification for Zinc-Coated Steel Structural Wire Rope
5. A653: Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

6. A1008: Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
 7. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 8. C518: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
 9. C534: Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 10. C916: Standard Specification for Adhesives for Duct Thermal Insulation
 11. C920: Standard Specification for Elastomeric Joint Sealants
 12. C1071: Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
 13. D3363: Standard Test Method for Film Hardness by Pencil Test
 14. E84: Standard Test Method for Surface Burning Characteristics of Building Materials
 15. E488: Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
- C. American Welding Society (AWS):
1. D1.1: Structural Welding Code – Steel
 2. D1.2: Structural Welding Code – Aluminum
 3. D1.3: Sheet Metal Welding Code
- D. North American Die Casting Association (NADCA):
1. ACR: Assessment, Cleaning and Restoration of HVAC Systems," "Section 5 - Cleanliness Verification and Documentation
- E. National Fire Protection Association (NFPA):
1. 45: Standard on Fire Protection for Laboratories Using Chemicals
 2. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems
- F. Sheet Metal and Air Conditioning Contractors National Association (SMANCA):
1. HVAC Air Duct Leakage Test Manual

2. HVAC Duct Construction Standards – Metal and Flexible
 3. IAQ Guidelines for Occupied Buildings under Construction
 4. Seismic Restraint Manual: Guidelines for Mechanical Systems
- G. Underwriters' Laboratories, Inc. (UL):
1. 181: UL Standard for Safety Factory-Made Air Ducts and Connectors
 2. 723: Standard for Safety Test for Surface Burning Characteristics of Building Materials
- 1.03 SUBMITTALS:
- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of the following products:
1. Liners and adhesives
 2. Sealants and gaskets
 3. Seismic-restraint devices
- C. Shop Drawings:
1. Factory- and shop-fabricated ducts and fittings
 2. Fittings
 3. Reinforcement and spacing
 4. Seam and joint construction
 5. Penetrations through fire-rated and other partitions
 6. Equipment installation based on equipment being used on Project
 7. Locations for duct accessories, including dampers, turning vanes, and access doors and panels
 8. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation
- D. Delegated-Design Submittal:
1. Sheet metal thicknesses

2. Joint and seam construction and sealing
3. Reinforcement details and spacing
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation] for selecting hangers and supports and seismic restraints.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 1. AWS D1.1, "Structural Welding Code - Steel," for hangers and supports
 2. AWS D1.2, "Structural Welding Code - Aluminum," for aluminum supports
 3. AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. Seismically brace duct hangers and supports in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
 1. Refer to the requirements in Section 01 41 20.

- C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.02 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS:

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches , select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SINGLE-WALL ROUND DUCTS AND FITTINGS:

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 48 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.04 SHEET METAL MATERIALS:

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653.
 - 1. Galvanized Coating Designation: G90.
- C. Stainless-Steel Sheets: Comply with ASTM A480, Type 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

- D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
 - E. Reinforcement Shapes and Plates: ASTM A36, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
 - F. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.
- 2.05 DUCT LINER:
- A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Manufacturers:
 - a. Knauf Fiberglass
 - b. Johns Manville
 - 2. Maximum Thermal Conductivity:
 - a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x degrees F at 75 degrees F mean temperature.
 - b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x degrees F at 75 degrees F mean temperature.
 - 3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized steel aluminum or stainless steel to match duct construction; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.06 SEALANT AND GASKETS:

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: -40 to plus 200 degrees F.
 9. Substrate: Compatible with galvanized sheet steel , stainless steel, or aluminum.
 10. Sealant shall have a VOC content of 420 g/L or less.
- C. Water-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.

4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel, stainless steel, or aluminum sheets.
10. Sealant shall have a VOC content of 420 g/L or less.
11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
12. Service: Indoor or outdoor.
13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric
2. Type: S
3. Grade: NS
4. Class: 25
5. Use: O
6. Sealant shall have a VOC content of 420 g/L or less

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.07 HANGERS AND SUPPORTS:

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.08 SEISMIC-RESTRAINT DEVICES:

- A. Refer to Sections 01 41 20 and 23 05 48 for requirements for restraint components and applications.

PART 3 - EXECUTION

3.02 DUCT INSTALLATION:

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

- C. Install ducts in maximum practical lengths with fewest possible joints.
 - D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
 - E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
 - F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
 - G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
 - H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
 - I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
 - J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 23 33 00 for fire and smoke dampers and specific installation requirements of the damper UL listing.
 - K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
 - L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
 - M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
 - N. Branch Connections: Use lateral or conical branch connections.
- 3.03 INSTALLATION OF EXPOSED DUCTWORK:
- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
 - B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.04 DUCTWORK EXPOSED TO WEATHER:

- A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.
- B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.
- C. Single Wall:
 - 1. Ductwork shall be galvanized steel or Type 316 stainless steel as indicated.
 - 2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 23 07 13.

3.05 ADDITIONAL INSTALLATION REQUIREMENTS FOR LABORATORY EXHAUST AND FUME HOOD EXHAUST DUCTS

- A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."
- B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.
- C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.

3.06 DUCT SEALING:

- A. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.

4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.07 HANGER AND SUPPORT INSTALLATION:

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet .
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.08 SEISMIC-RESTRAINT-DEVICE INSTALLATION:

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", Sections 01 41 20 and Section 23 05 48.
- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.09 CONNECTIONS:

- A. Make connections to equipment with flexible connectors complying with Section 23 33 00.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.10 FIELD QUALITY CONTROL:

- A. Perform tests and inspections.
- B. Leakage Tests:
 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 2. Test the following systems:
 - a. Supply Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Return Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - c. Exhaust Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - d. Outdoor-Air Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 5. Test for leaks before applying external insulation.
 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at

maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

7. Give seven days' advance notice for testing.

3.11 DUCT CLEANING:

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use duct cleaning methodology as indicated in NADCA ACR.
- C. Use service openings for entry and inspection.
 1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 for access panels and doors.
 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling to gain access during the cleaning process.
- D. Particulate Collection and Odor Control:
 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- E. Clean the following components by removing surface contaminants and deposits:
 1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 4. Coils and related components.
 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.12 STARTUP:

- A. Air Balance: Comply with requirements in Section 23 05 93.

3.13 DUCT SCHEDULE:

- A. Fabricate ducts with materials indicated above and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

- B. Supply Ducts:

1. Ducts Connected to Fan Coil Units and Terminal Units:
 - a. Pressure Class: Positive 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.

- c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
 - 2. Ducts Connected to Constant and Variable Volume Air-Handling Units and Makeup Air Units:
 - a. Pressure Class: Positive 3 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- C. Return Ducts:
 - 1. Ducts Connected to Fan Coil Units and Terminal Units:
 - a. Pressure Class: Positive or negative 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
 - 2. Ducts Connected to Air-Handling Units and Makeup Air Units:
 - a. Pressure Class: Positive or negative 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
 - 2. Ducts Connected to Air-Handling Units:

- a. Pressure Class: Positive or negative 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 8.
3. Ducts Connected to High-Humidity Locations:
- a. Type 316, stainless-steel sheet.
 - b. Exposed to View: No. 4 finish.
 - c. Concealed: No. 2D finish.
 - d. Welded longitudinal seams; welded or flanged transverse joints with water-tight EPDM gaskets.
 - e. Pressure Class: Positive or negative 3 inch wg.
 - f. Airtight/watertight.
4. Ducts Connected to Fans Exhausting Fume Hood (ASHRAE 62.1, Class 3 and Class 4) Air:
- a. Type 316, stainless-steel sheet.
 - (1) Exposed to View: No. 4 finish.
 - (2) Concealed: No. 2B finish.
 - b. Pressure Class: Positive or negative 3 inch wg.
 - c. Minimum SMACNA Seal Class A Welded seams and joints.
 - d. Airtight/watertight.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Fan Coil Units and Terminal Units:
- a. Pressure Class: Positive or negative 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
2. Ducts Connected to Air-Handling Units and Makeup Air Units:

- a. Pressure Class: Positive or negative 2 inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- F. Intermediate Reinforcement:
- 1. Galvanized-Steel Ducts: Galvanized steel.
 - 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- G. Liner where indicated on plans:
- 1. Supply-Air Ducts: Fibrous glass, Type I 1 inch(es) thick.
 - 2. Return-Air Ducts: Fibrous glass, Type I 1 inch(es) thick.
 - 3. Supply Fan Plenums: Fibrous glass, Type I 1 inch(es) thick.
 - 4. Return Plenums: Fibrous glass, Type I 1 inch(es) thick.
- H. Elbow Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - (1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - b. Velocity 1000 or Higher:
 - (1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

- b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
- a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - (1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - (2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - (3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

3.14 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 31 16
NONMETAL DUCTS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide nonmetal ducts as indicated and in compliance with Contract Documents.
 - 1. Thermoset FRP ducts and fittings.

1.02 REFERENCES:

- A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 62.1: Ventilation for Acceptable Indoor Air Quality
 - 2. 90.1: Energy Standard For Buildings Except Low-Rise Residential Buildings
- B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - 1. SMACNA's "Thermoset FRP Duct Construction Manual."
- C. National Fire Protection Association (NFPA):
 - 1. 45: Standard on Fire Protection for Laboratories Using Chemicals
 - 2. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems
- D. Underwriters' Laboratories, Inc. (UL):
 - 1. 181: UL Standard for Safety Factory-Made Air Ducts and Connectors
 - 2. 723: Standard for Safety Test for Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of the following products:
 - 1. Sealants and gaskets
 - 2. Seismic-restraint devices

C. Shop Drawings:

1. Factory- and shop-fabricated ducts and fittings
2. Fittings
3. Reinforcement and spacing
4. Seam and joint construction
5. Penetrations through fire-rated and other partitions
6. Equipment installation based on equipment being used on Project
7. Locations for duct accessories, including dampers, turning vanes, and access doors and panels
8. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation

D. Delegated-Design Submittal:

1. Joint and seam construction and sealing
2. Reinforcement details and spacing
3. Materials, fabrication, assembly, and spacing of hangers and supports.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Protect shop fabricated and factory purchased ductwork, accessories, and purchased products from damage during shipping, storage, and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

- C. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with the following and with the Works' performance requirements and design criteria:
 - 1. SMACNA's "Thermoset FRP Duct Construction Manual."
 - 2. Static-Pressure Classes:
 - a. Exhaust Ducts (Negative Pressure): 1-inch wg.
- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions to comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
 - 1. Refer to the requirements in Section 01 41 20.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 – "Airstream Surfaces."
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.02 THERMOSET FRP DUCTS AND FITTINGS

- A. Duct and Fittings:
 - 1. Thermoset FRP Resin: Comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.
 - 2. Round Duct: ASTM D2996, Type I, Grade 2, Class E, filament-wound duct, minimum 0.125-inch wall thickness, with tapered bell-and-spigot ends for adhesive joints or with plain ends with couplings.

3. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.
4. Joining Materials: Roving and polyester resin.
5. Fabrication:
 - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."

2.03 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Zinc-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables: ASTM A492, stainless-steel cables with end connections made of stainless-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports: Steel shapes complying with ASTM A36/A36M.

2.04 SEISMIC-RESTRAINT DEVICES

1. Refer to Sections 01 41 20 and 23 05 48 for requirements for restraint components and applications.

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install duct sections in maximum practical lengths with fewest possible joints.

- C. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- D. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- F. Install ducts with a minimum clearance of 1 inch, plus allowance for insulation thickness.
- G. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- H. Where ducts pass through non-fire-rated interior partitions and exterior walls, and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches.
- I. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code and by authorities having jurisdiction. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the fire damper UL listing.
- J. Install dampers and all other duct-mounted accessories in air ducts where indicated on Drawings.
- K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- L. Elbows: Use long-radius elbows wherever they fit.
- M. Branch Connections: Use lateral or conical branch connections.
- N. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."

3.02 HANGER AND SUPPORT INSTALLATION:

- A. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 6, "Hangers and Supports."
 - 1. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.03 SEISMIC-RESTRAINT-DEVICE INSTALLATION:

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 2. Brace a change of direction longer than 12 feet.
- B. Select sizes of components so strength will be adequate to carry present and future static and seismic loads within restraint device capacity.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints where ducts are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and water and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.04 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative.
- E. Leakage Tests:
 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 2. Where static pressure and leakage values shown below differ from those in the SMACNA manual, the more stringent values shall apply.
 3. Test the following systems:
 - a. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
 4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 6. Give seven days' advance notice for testing.

F. Duct System Cleanliness Tests:

1. Test protocols shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems," "Section 5 - Cleanliness Verification and Documentation."
2. Visually inspect duct system to ensure that no visible contaminants are present.
3. Test sections of fibrous-glass duct system chosen randomly by Owner for cleanliness according to "Method 2 Protocol."
4. Test sections of Phenolic-foam, Thermoset FRP, PVC, and CPVC duct systems chosen randomly by Owner, for cleanliness according to "Method 3 - NADCA Vacuum Test."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

G. Duct system will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.05 DUCT CLEANING

A. Clean duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Section 23 33 00 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. All duct cleaning shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
4. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for washdown procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removing surface deposits and debris.

3.06 STARTUP SERVICE

- A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.07 DUCT SCHEDULE

- A. Indoor Ducts and Fittings:

1. Thermoset FRP Round Ducts and Fittings

3.08 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Section Includes:

1. Manual volume dampers.
2. Control dampers.
3. Fire dampers.
4. Combination smoke and fire dampers.
5. Turning vanes.
6. Duct-mounted access doors.
7. Flexible connectors.
8. Duct accessory hardware.

1.02 REFERENCES:

A. Air Movement and Control Association International, Inc. (AMCA):

1. 500-D: Laboratory Methods of Testing Dampers for Rating

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. 90.1: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings

C. ASTM International (ASTM):

1. A480: Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
2. A653: Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

3. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
4. E84: Standard Test Method for Surface Burning Characteristics of Building Materials
5. E477: Standard Test Method for Laboratory Measurements of Acoustical and Air-flow Performance of Duct Liner Materials and Prefabricated Silencers

D. National Fire Protection Association (NFPA):

1. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems

E. Underwriters' Laboratories, Inc. (UL):

1. 181: Standard for Safety Factory-Made Air Ducts and Connectors
2. 555: Standard for Safety Fire Dampers

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
- C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.
- D. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION:

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems" and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 MATERIALS:

- A. Galvanized Sheet Steel: Comply with ASTM A653.
 - 1. Galvanized Coating Designation: G90.
- B. Stainless-Steel Sheets: Comply with ASTM A480, Type 316, and having a No. 4 finish.
- C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T5.
- E. Hard Aluminum: Comply with ASTM B221, Alloy 6065 T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

2.03 MANUAL VOLUME DAMPERS:

A. Single Blade Dampers:

1. Material: Fabricate from same material as duct, but one sheet metal thickness heavier. V-groove stiffened.
2. Configuration: Size and configuration to recommendations of SMACNA, except maximum height 8 inches.
3. Control: Locking quadrant with shaft extension to accommodate insulation thickness.
4. Shaft: Continuous.
5. Bearings: Inside and outside bronze end bearings.
6. Frame: Channel frame of same material as adjacent duct, complete with angle stop.

B. Multi-Bladed Dampers:

1. Material: Factory manufactured of material compatible with duct. Metal thickness and construction to recommendations of SMACNA.
2. Blade Height: Maximum blade height: 8 inches.
3. Bearings: Bronze bushings.
4. Shaft: Continuous.
5. Configuration: Linkage with opposed blade operation.
6. Control: Shaft extension with locking quadrant.
7. Frame: Channel frame of same material as adjacent duct, complete with angle stop.

2.04 CONTROL DAMPERS

- A. Refer to Section 23 09 23.12 requirements for control dampers.

2.05 FIRE DAMPERS:

A. Manufacturers:

1. E H Price
2. Ruskin

3. Nailor
 4. Greenheck
 5. Titus
 6. Or equal
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Fire Rating: 1-1/2 and 3 hours to suite separation rating.
- D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners. Provide stainless steel to match duct construction or in corrosive atmospheres.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: As indicated in manufacturer's instructions to meet code requirements, and of length to suit application.
- F. Mounting Orientation: Vertical or horizontal as required.
- G. Blades: Roll-formed, interlocking, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 degrees F rated, fusible links.
- 2.06 COMBINATION SMOKE AND FIRE DAMPERS
- A. Manufacturers:
1. Ruskin
 2. E H Price
 3. Greenheck
 4. Nailor
 5. Titus
 6. Or equal
- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with interlocking, gusseted or mechanically attached corners and mounting flange.
- F. Heat-Responsive Device: Resettable, 165 deg F rated, fusible links.
- G. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.
- H. Smoke Detector: Integral, factory wired for single-point connection.
- I. Blades: Roll-formed, horizontal, interlocking, 0.063-inch-thick, galvanized sheet steel.
- J. Rated pressure and velocity to exceed design airflow conditions.
- K. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.
- L. Master control panel for use in dynamic smoke-management systems.
- M. Damper Motors: Modulating or two-position action.
- N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for fire alarm panel.
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.
- O. Accessories:
1. Auxiliary switches for signaling or position indication.
 2. Test and reset switches, remote mounted.
- 2.07 TURNING VANES:
- A. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
 - B. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.
- 2.08 DUCT-MOUNTED ACCESS DOORS:
- A. Manufacturers:
 1. Ductmate
 2. Duro Dyne
 3. Ruskin
 4. Nailor
 5. Greenheck
 6. Titus
 7. Or equal
 - B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
 - a. Access Doors Less than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with handles.
 - d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with handles.

2.09 FLEXIBLE CONNECTORS:

A. Manufacturers:

1. Duro Dyne
2. Ductmate
3. Ventfabrics

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip minimum 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling
3. Service Temperature: Minus 40 to plus 200 degrees F

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weather-proof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling
3. Service Temperature: Minus 50 to plus 250 degrees F

- G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling
3. Service Temperature: Minus 67 to plus 500 degrees F

2.10 DUCT ACCESSORY HARDWARE:

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 1. Install steel volume dampers in steel ducts.
 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.

- G. Install dampers according to UL listing.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-foot spacing.
 - 8. Upstream and downstream from turning vanes.
 - 9. Control devices requiring inspection.
 - 10. Elsewhere as indicated.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches
 - 2. Two-Hand Access: 12 by 6 inches
 - 3. Head and Hand Access: 18 by 10 inches
 - 4. Head and Shoulders Access: 21 by 14 inches
 - 5. Body Access: 25 by 14 inches
 - 6. Body plus Ladder Access: 25 by 17 inches
- K. Label access doors according to Section 23 05 53 to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.

- M. For fans developing static pressures of 5-inch w.g. and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- N. Connect diffusers to ducts directly.
- O. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- P. Install duct test holes where required for testing and balancing purposes.
- Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.02 FIELD QUALITY CONTROL:

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

3.03 CLOSEOUT ACTIVITIES:

- #### A.
- Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 34 00
FANS AND ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide fans and accessories as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. Air Movement and Control Association Inc. (AMCA):
 - 1. 210: Laboratory Methods of Testing Fans for Rating
 - 2. 211: Certified Ratings Program – Product Rating Manual for Fan Air Performance
 - 3. 300: Reverberant Room Method for Sound Testing of Fans
 - 4. 311: Certified Sound Ratings Program for Air Moving Devices
- B. American National Standards Institute (ANSI):
 - 1. S2.19: Mechanical Vibration – Balance Quality Requirements for Rigid Rotors
- C. ASTM International (ASTM):
 - 1. B117: Standard Practice for Operating Salt Spray (Fog) Apparatus
- D. The Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. 519: Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- E. National Fire Protection Association (NFPA):
 - 1. 90A: Standard for the Installation of Air Conditioning and Ventilating Systems

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Shop Drawings: Submit complete material, construction and performance shop drawings for fans and accessories. Include the following:
 - 1. Certified fan performance curves.

2. For fans where sound data is scheduled, certified sound power data which conforms to specified levels.
 3. Complete motor data, including manufacturer.
 4. Complete accessories data, including drawings (i.e., disconnects, curbs, dampers, belts, bearings, sheave sizes, coatings, etc.).
- C. Delegated Design Submittals: For each device, equipment or appurtenance provide written certification from Professional Engineer licensed in the State of Utah stating that supports systems and anchorage for equipment have been designed according to the requirements of Section 1613 of the building codes of Utah, Salt Lake City and ASCE/SEI 7, and in accordance with Specification 01 41 20. Submit calculations stamped by a Professional Engineer licensed in the State of Utah for support systems and anchorage for wind, seismic, and all other pertinent loads.
- D. Shop Drawings must confirm that proposed fan equipment conforms to requirements of this Section of the Specification.
- 1.04 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.05 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
- 1.06 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

- 2.01 GENERAL:
- A. Incorporate any requirements not listed here for each individual fan as noted on the Equipment Schedules on the drawings.
- 2.02 INLINE CENTRIFUGAL FANS:
- A. Inline centrifugal fans as per the Drawing schedule, each UL certified and labelled, and each AMCA certified and labelled for air and sound performance in accordance with tests performed to AMCA Standards 210 and 300. Each fan is to be complete with:
1. Housing: Rigid structural galvanized steel framework with formed galvanized steel panels including a flanged inlet panel with fan inlet Venturi, a flanged discharge panel and two removable access panels to permit servicing and/or removal of all interior components without disturbing duct connections.

2. Housing Insulation: Factory applied, neoprene spray coated glass fiberboard material meeting NFPA 90A requirements and permanently secured in place.
3. Wheel: Centrifugal, non-overloading aluminum wheel, statically and dynamically balanced, complete with backwardly inclined blades and an inlet cone matched to the housing inlet panel Venturi.
4. Fan Shaft and Bearings: Ground and polished steel shaft sized for a first critical speed of at least 25 percent over the maximum fan operating speed and mounted in permanently sealed and lubricated pillow block ball type bearings sized for an AFBMA L-50 average life of 200,000 hours at maximum fan RPM.
5. Drive and Guard: Adjustable V-belt drive sized for 150 percent of motor nameplate horsepower, and complete with an adjustable cast iron motor pulley, and a removable galvanized steel combination OSHA motor cover/belt guard.
6. Motor: A motor conforming to requirements specified in Section 26 20 00, factory wired to a NEMA 4 disconnect mounted on the fan housing and motor and drive to be mounted out of the airstream.
7. Mounting Hardware Kit: Galvanized steel mounting brackets for all four corners, and spring type vibration isolators provided by the fan manufacturer sized to suit the fan weight and mounting arrangement, all supplied loose for field installation.
8. Wire Mesh Guard: Removable 1/2-inch x 1/2-inch welded galvanized steel wire mesh in a galvanized steel frame sized to cover the open end of the fan.
9. Disconnect switches: Factory supplied, mounted and wired with housing suitable to exposure.

B. Manufacturers:

1. Greenheck Fan Corp
2. Loren Cook
3. Twin City Fan and Blower
4. Or equal

2.03 CEILING EXHAUST FANS:

- A. Ceiling exhaust fans as per the Drawing schedule, each UL certified and labelled, and each AMCA certified and labelled for air and sound performance in accordance with tests performed to AMCA Certification Programs 211 and 311. Fans are to be complete with:
 1. Fan Housing: Steel housing with electrical receptacle and box, electrical connection access cover, and an outlet duct connection collar with backdraft damper.

2. Fan Wheel/Motor Assembly: Removable fan-motor assembly with forward curved balanced centrifugal wheel direct connected to a permanently lubricated, overload protected and vibration isolated motor which is equipped with a length of prewired power cord with plug for plug-in connection/disconnection at the housing receptacle.
3. Exhaust Grille: White, non-yellowing plastic exhaust grille.
4. Accessories: For fans as per the Drawing schedule and/or details, factory supplied accessories as follows:
 - a. An exterior discharge accessory with integral birdscreen and backdraft damper.
 - b. A ULC listed ceiling radiation damper meeting NFPA 90A requirements.
 - c. A washable aluminum mesh filter.

B. Manufacturers:

1. Greenheck Fan Corp
2. Loren Cook
3. Twin City Fan and Blower
4. Carnes Company

2.04 HOODED TYPE GRAVITY VENTILATORS:

- A. Low silhouette, rectangular, roof mounting hooded penthouse type ventilators as per the drawing schedule, each constructed of aluminum, supplied in knock-down form for site assembly, and each complete with:
1. Full 360 degree perimeter hood opening.
 2. 1/2-inch x 1/2-inch aluminum mesh birdscreen.
 3. A welded aluminum, minimum 12 inch high insulated roof mounting curb with damper tray and curb seal.
 4. An aluminum backdraft damper, for installation in the roof curb damper tray if scheduled.
 5. A motorized aluminum damper, for installation in the roof curb damper tray if scheduled.

B. Manufacturers:

1. Greenheck Fan Corp
2. Twin City Fan and Blower Co
3. PennBarry
4. Carnes Company

PART 3- EXECUTION

3.01 GENERAL:

- A. The installation of all fans is to meet the seismic restraint requirements as stated in Section 01 41 20 and Section 23 05 48.

3.02 INSTALLATION OF CENTRIFUGAL INLINE FANS:

- A. Provide inline centrifugal fans where shown.
- B. Provide flexible duct connectors.
- C. Install with motor on the bottom or side for ease of servicing.
- D. Install mounting brackets for each fan and secure in place with vibration isolators and hanger rods, independent of connecting ductwork.

3.03 INSTALLATION OF CEILING EXHAUST FANS:

- A. Provide ceiling exhaust fans where shown.
- B. Rigidly secure each fan housing in place in the ceiling space and coordinate installation with:
1. The air distribution work where duct connection are specified.
 2. The electrical work of Division 26 where electrical power connection to the housing receptacle is specified.
- C. Install fan-motor assemblies and plug into housing receptacles.
- D. Install accessories supplied loose.
- E. When installation is complete, check and test operation and adjust as required.

3.04 INSTALLATION OF ROOF MOUNTED GRAVITY VENTILATORS:

- A. Provide roof mounted gravity ventilators where shown.
- B. Supply a roof mounting curb with each ventilator and hand the curbs to the roofing trade on the roof for mounting and flashing into roof construction as part of the roofing work.
- C. Install dampers in the curb damper tray and secure in place.
- D. Secure ventilators in place on the curbs.

3.05 CONTROLS:

- A. Coordinate with HVAC control contractor to ensure tie-in between BMS controllers and VFD hard-wired control circuit.

3.06 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

3.07 SCHEDULES:

- A. See Drawings.

END OF SECTION

SECTION 23 37 13.13

AIR DIFFUSERS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide square ceiling diffusers and high-capacity drum louver diffusers as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 70: Method of Testing the Performance of Air Outlets and Air Inlets

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 HORIZONTAL SQUARE CEILING DIFFUSERS:

- A. Manufacturers:
 - 1. Titus
 - 2. Price
 - 3. Nailor
 - 4. Or equal
- B. Material: Steel
- C. Finish: Powder Coat, white
- D. Face Size: As scheduled or indicated on drawings
- E. Face Style: Square Plaque
- F. Mounting: Surface or T-bar to match ceiling
- G. Pattern: Fixed Horizontal
- H. Dampers: None

2.02 HIGH-CAPACITY DRUM LOUVER DIFFUSERS:

- A. Manufacturers:
 - 1. Titus
 - 2. Price
 - 3. Nailor
 - 4. Or equal
- B. Airflow Principle: Extended distance for high airflow rates
- C. Material: Aluminum, heavy gage extruded
- D. Finish: Powder Coat
- E. Border: 1-1/4-inch width with countersunk screw holes
- F. Gasket between drum and border

- G. Body: Drum shaped; adjustable vertically
- H. Blades: Individually adjustable horizontally
- I. Mounting: Surface
- J. Size: As scheduled or indicated on drawings
- K. Accessories:
 - 1. Manual volume damper with hand quadrant.

2.03 SOURCE QUALITY CONTROL:

- A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Review the architectural reflected ceiling plan and confirm the indicated diffuser mounting style is compatible the ceiling type. Any conflicts are to be brought to the Engineer's attention for resolution.
- D. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING:

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 37 13.23
REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide grilles as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

- 1. 70: Method of Testing the Performance of Air Outlets and Air Inlets

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 GRILLES:

A. Aluminum Fixed Blade Face Return/Exhaust/Relief Grille:

1. Manufacturers:
 - a. Titus
 - b. Price
 - c. Nailor
 - d. Or equal
2. Make/Model: Per Equipment Schedule
3. Material: Extruded Aluminum
4. Finish: Powder Coat
5. Face Blade Arrangement: Fixed 45 degree deflection louvers spaced 3/4 inch on center
6. Frame: 1-1/4 inches wide
7. Mounting: Countersunk screw for surface mounted, aluminum infill module for T-bar.
8. Damper Type: None

B. Aluminum Adjustable Blade Face Supply Grille:

1. Manufacturers:
 - a. Titus
 - b. Price
 - c. Nailor
 - d. Or equal
2. Make/Model: Per Equipment Schedule
3. Material: Aluminum
4. Finish: Powder Coat

5. Face Blade Arrangement: Adjustable double deflection with front and rear blades spaced 3/4 inch on center unless otherwise scheduled.
6. Frame: 1-1/4 inches wide
7. Mounting: Countersunk screw for surface, lay-in no screw hole for T-bar
8. Damper Type: None

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine areas where grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

- A. Install grilles level and plumb.
- B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING:

- A. After installation, adjust and grilles to air patterns indicated, or as directed, before starting air balancing.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 41 00

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide flat panel filters, pleated panel filters, front- or back-access filter frames, side-access filter housings, filter gauges as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
- B. National Fire Protection Association (NFPA):
 - 1. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems
- C. Underwriters' Laboratories, Inc. (UL):
 - 1. 900: Standard for Safety Air Filter Units

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 - 2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

- D. Seismic Qualification Data: Certificates, for filters, accessories, and components from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.
- F. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Provide one complete set(s) of filters for each filter bank.

1.04 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Deliver and store products in a clean, dry place.
- C. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- D. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- E. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.

2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and criteria documented in Section 01 41 20.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Component Importance Factor: 1.5.
- B. ASHRAE Compliance:
 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- C. Comply with NFPA 90A.
- D. Comply with UL 900.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 PLEATED PANEL FILTERS:

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Capacities and Characteristics:
 1. Face Size: As per equipment schedule

2. Depth: 2 inches nominal.
 3. Initial Resistance: 0.1-inch wg at 350 fpm.
 4. Recommended Final Resistance: 1.0 inches wg.
 5. Minimum Efficiency Reporting Value: MERV 8, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
 6. Access: Side.
- D. Media: Cotton and synthetic fibers or 100 percent synthetic fibers coated with non-flammable adhesive.
1. Separators shall be bonded to the media to maintain pleat configuration.
 2. Welded-wire or expanded metal grid shall be on downstream side to maintain pleat.
 3. Media shall be bonded to frame to prevent air bypass.
- E. Filter-Media Frame: Moisture resistant two piece cardboard frame with diagonal supports sealed or bonded to the media.

2.03 SIDE-ACCESS FILTER HOUSINGS:

- A. Description: Factory-assembled, side-service housings, constructed of to match duct material, with flanges to connect to duct or casing system.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Prefilters: Integral tracks to accommodate 2-inch thick, disposable filters.
- D. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.
- E. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.04 FILTER GAUGES:

- A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 1. Manufacturers:
 - a. Dwyer – 2000 Magnehelic

- B. Source Limitations: Obtain from single source from single manufacturer.
 - 1. Diameter: 4-1/2 inches.
 - 2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.
- C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF FILTERS:

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gauge for each filter bank.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- E. Coordinate filter installations with duct and air-handling-unit installations.

3.03 INSTALLATION OF FILTER GAUGES:

- A. Install filter gauge for each filter bank.
- B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.04 CONTROL CONNECTIONS:

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between pressure sensors and control system.

3.05 CLEANING:

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

3.06 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 51 33

INSULATED SECTIONAL CHIMNEYS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Double Wall Stainless Steel Vent

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.
 - 2. Layout Drawings
 - 3. Sizing Calculations if applicable
 - 4. Product Catalog
 - 5. Installation Instructions
 - 6. Warranty
- B. Shop Drawings: For chimneys and stacks.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of hangers and seismic restraints.

1.04 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For factory-fabricated chimneys and stacks, accessories, and components from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Sample Warranty: For special warranty.

1.05 QUALITY ASSURANCE

- A. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.06 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, structural failures caused by expansion and contraction.
2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 DOUBLE WALL STAINLESS STEEL VENT

- A. Z-Vent Double Wall by Z-Flex or approved equivalent
- B. UL1738 and ULC-S636 Listed.
- C. The factory built double wall vent shall be engineered for use with category I, II, III or IV gas fired appliances or as specified by the gas fired appliance manufacturer.
- D. Inner vent shall be constructed of UL Listed UNS S44735 (i.e. AL 29-4C®) superferritic stainless steel or UL Listed alternate.
- E. The outer double wall shall be constructed of 304 or 316 stainless steel and have a 1“ insulating air space around the inner vent to outer double wall.
- F. The outer double wall shall incorporate a joint closure system which includes a snap lock or flanges with ZV-Clamp.
- G. Double wall vent shall be compatible to single wall & smoothcore flexible vents with an adaptor all from the same vent manufacturer.
- H. Maximum UL rated vent gas temperature shall not exceed 550°F for up to 12“ diameter vents and 480°F for 14“ to 24“ diameter vents.

- I. Vent shall be UL rated for a maximum pressure of 8" w.c. and shall have passed UL leakage test at 20" w.c.
- J. The vent system shall be continuous from the appliance's flue outlet to the vent termination outside the building. All systems components such as vent supports, roof or wall penetrations, terminations, appliance connectors and drain fittings shall be UL/cUL listed and supplied by the same vent manufacturer.
- K. Vent components in direct contact with products of combustion must include a UL/cUL label.
- L. Inner vent shall include a factory installed Double Fail Safe FKM gasket in the female end of the vent yielding an air and water tight joint when the overlapping ends are assembled.
- M. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Exhaust Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
 - 2. Intake Termination: Gooseneck with birdscreen.

2.02 GUYING AND BRACING MATERIALS

- A. No guying is allowed.
- B. Vents must be self-supported above the roof.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATION

- A. Listed Double Wall Stainless Steel: High-efficiency boiler or furnace vents in masonry chimney.

3.03 INSTALLATION OF LISTED CHIMNEYS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 22 00 "Roof Accessories."

- B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- D. Lap joints in direction of flow.
- E. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

3.04 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- B. Provide temporary closures at ends of chimneys and stacks that are not completed or connected to equipment.

END OF SECTION

SECTION 23 52 19
HOT WATER BOILERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:

- 1. Copper finned-tube, high efficiency, forced draft, gas-fired, non-condensing hot water boilers.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data including rated capacities of selected model clearly indicated, weights, furnished specialties, and accessories, and installation and startup instructions.

- B. Shop Drawings:

- 1. Submit manufacturer's assembly type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
 - 2. Wiring Diagrams: Manufacturer's electrical requirements for power supply wiring to terminal units.
 - 3. Manufacturer's ladder type for interlock and control wiring. Differentiate between portions of wiring factory installed and portions to be field installed.

- C. Operation and Maintenance (O&M) Data:

- 1. Maintenance instructions including lubrication instructions, control motor and drive replacement, and spare parts lists.
 - 2. Include O&M data, product data, and Shop Drawings in single bound manuals.

- D. Warranty and Test Certificates.

- E. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of copper finned-tube, high-efficiency, non-condensing, hot water boilers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 yrs.
- B. Entire boiler system and its installation shall conform to the manufacturer's instructions, applicable local, state and federal codes and associated National Board requirements.
- C. Boilers must be fully factory test fired prior to shipment. Manufacturer shall supply copies of the Test Fire Report, including fuel/air settings and combustion test results.
- D. Regulatory Requirements:
 - 1. Provide hot water boilers tested and rated in accordance with Hydronics Institute and bearing HI emblem on nameplate affixed to boiler.
 - 2. National Fire Protection Association (NFPA) Compliance: Install copper finned-tube, high efficiency, non-condensing, hot water boilers in accordance with NFPA No. 54.
 - 3. ASME Compliance: Construct Install copper finned-tube, high efficiency, non-condensing, hot water boilers in accordance with ASME Boiler and Pressure Vessel Code, Section IV.
 - 4. Underwriters Laboratories (UL) Labels: Provide Install copper finned-tube, high efficiency, non-condensing, hot water boiler ancillary electrical components UL labeled

1.05 WARRANTY

- 1. Heat exchanger and burner shall be covered for a period of ten (10) years against failure due to material defects, thermal shock, or workmanship, providing the boiler is installed in a closed loop system and in accordance with all requirements outlined in the equipment manual.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Handle hot water boilers and equipment carefully to prevent damage, breaking, and scoring. Do not install damaged boilers or components; replace with new.
- B. Store hot water boilers and equipment in clean, dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturer's equipment used as basis of design for this project is name indicated in schedule contained in these Contract Documents. If no manufacturer is listed, basis of design is industry standard indicated.
 - 1. Thermal Solutions
 - 2. Aerco
 - 3. Or equivalent

2.02 BOILER CONSTRUCTION

- A. Boiler shall be construction and stamped in accordance with Section IV of the ASME Code of low pressure heating boilers with a maximum water working pressure of 160 PSIG. Form H-3 Manufacturer's Data Report for Water Tube Boilers shall be provided.
- B. Combustion chamber shall be enclosed in a minimum 18-gauge stainless steel airtight inner jacket. The outer jacket shall be finished, both inside and outside, with a powder coat finish and be equipped with a sight glass.
- C. Boiler shall be capable of operating at full rated capacity with natural gas or propane gas pressure at the inlet of the boiler gas train of 3.5" to 14" W.C. and have full modulation.

2.03 BOILER DESIGN

- A. Blower motor shall be variable speed with pulse width modulation control. The variable speed drive must be built into the fan motor with no separate drives required.
- B. Boilers shall be 5:1 turndown or greater, with infinite turndown between 20% and 100% of input. Both air and gas volume must be varied to maintain proper combustion at all firing rates.
- C. The thermal efficiency of the boiler shall be 88% minimum at its low fire condition, operating with a 20 degree temperature differential with 140 degree F return water temperature.
- D. Trim shall include a combination temperature/pressure gauge and an ASME-rated pressure relief valve set at 60 PSI.
- E. Boiler shall be provided with a flow switch installed in the water outlet connection.

2.04 CONTROLS

- A. Control system shall be supplied for 120 volts, single phase, and 60 hertz.

- B. Limit circuit shall include an integral high-limit temperature controller with a field adjustable range of 180oF to 240oF, water flow switch, differential switch to sense air flow to the burner, manual reset low and high gas pressure switches, and a blocked exhaust switch.
- C. Provide a probe type, manual reset low water cut off.
- D. Boiler shall include electronic direct spark ignition.
- E. Control shall have the following integrated control functions:
 - 1. Primary Flame Safeguard Control
 - 2. Spark Generator
 - 3. Firing Rate Limiting
 - 4. PID Load Control
 - 5. Time of Day
 - 6. Pulse Width Modulation for Variable Speed Drive on the Blower Motor
 - 7. Auxiliary Output Control (3 Outputs for Pump Control)
 - 8. Fault Code History Including Equipment Status at time of Lockout
 - 9. Alert Code Status including equipment status at time of internal alerts
 - 10. Three Status LED's (Power, Flame and Alarm)
 - 11. Flame Sensing (Ultraviolet Sensors, Flame Rod)
 - 12. Analog Inputs:
 - a. Outlet Limit and Temperature
 - b. Stack Limit and Temperature
 - c. Inlet Temperature and Outdoor Temperature
 - d. Pulse Width Modulation Feedback
 - e. Flame Signal from either a Flame Rod or Ultraviolet Detector
 - f. 4-20mA Control Input
 - 13. Digital Inputs:

- a. Programmable Pre Ignition Interlock
 - b. Programmable Load/Limit Control Input
 - c. Programmable Interlock
 - d. Programmable Annunciation
 - e. Time of Day
14. Analog Outputs:
- a. Modulation – Pulse Width Modulation for Variable Frequency Drives
15. Digital Outputs:
- a. Auxiliary Output Control (3 outputs)
 - b. Combustion Blower
 - c. External Ignition
 - d. Main Gas Valve
 - e. Alarm
- F. Local operator interface shall include the following features:
- 1. Individual boiler status, configuration, history and diagnostics.
 - 2. Allows configuration and monitoring of the burner control sequence, flame signal, diagnostics, historical files and faults.
 - 3. Allows boiler naming.
 - 4. Color 3.5” x 4.625” (5.7” diagonal) user interface display.
 - 5. LED Indicators
 - 6. Flush Mounting
 - 7. Touch screen disable for screen cleaning
 - 8. Screen saver
 - 9. Contrast control
 - 10. Volume control
 - 11. Graphic user interface

12. UL Approval

- G. Provide boiler sequencing system to maximize efficiency for the boiler plant.

2.05 MAIN GAS TRAIN COMPONENTS

- A. Boiler shall have an integral gas train, factory assembled and installed. The main gas train will include:

1. Minimum incoming gas pressure of 3.5 in. w.c. Maximum incoming gas pressure of 14 in. w.c.
2. One manual shut-off valve at gas inlet.
3. Gas regulating valve.
 - a. Main valve body with two shutoff seats (double block valve).
 - b. Closing time less than one second.
 - c. Mesh screen (strainer) between inlet flange and main body.
 - d. Position indication lights for each valve stage
 - e. Class H insulation solenoid valves.
 - f. Aluminum alloy, die cast body material.
 - g. Hydrocarbon resistant NBR and rubber type seals and gaskets.
 - h. 120V, Single Phase, 60 Hertz Power Required.
 - i. UL Approval.
4. High and low gas pressure switches.
5. Fuel train shall not contain components that require ventilation to the outdoors.
6. Boiler shall initiate combustion with direct spark ignition. No pilot assembly shall be utilized.
7. Gas train shall comply with current CSD-1 fuel train codes.
8. All components of the gas train shall be IRI approved.

2.06 BOILER FITTINGS

- A. Boiler shall be supplied with an ASME Section IV approved, side outlet type safety relief valve. The safety relief valve shall be in accordance with ASME code requirements.

- B. Temperature/pressure gauge shall be included with the boiler.
- C. Boiler shall have the following accessories and options available at the time of purchase:
 - 1. Air inlet filter kit
 - 2. Low water cut off probe
 - 3. Fused external disconnect
 - 4. Alarm horn with silence switch
 - 5. Stack temperature thermometer
 - 6. Condensate drain kit

2.07 EMISSIONS

- A. Boiler shall operate with CO emissions less than 30 PPM corrected to 3% O₂ and shall operate with NO_x emissions less than 30 PPM corrected to 3% O₂ over the turndown range.

2.08 OPERATIONS MANUAL

- A. Instructions for installation, operation and maintenance of the boiler shall be contained in a manual provided with each boiler unit.
- B. Wiring diagram corresponding to the boiler configuration shall be permanently affixed to the boiler near the electrical panel.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions under which copper finned-tube high efficiency, non-condensing hot water boilers are to be installed. Do not proceed with Work until unsatisfactory conditions corrected.
- B. Equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.

3.02 INSTALLATION OF HOT WATER BOILERS

- A. Comply with boiler manufacturer's written instructions for installation, except as otherwise indicated.
- B. Comply with installation requirements of local and state boiler codes and applicable provisions of NFPA and ASME boiler code standards.

- C. Install hot water boilers on 4 in. high concrete pad where indicated and maintain manufacturer's recommended clearances around and over top of boilers.
- D. Install boiler trim.
- E. Install electrical control items furnished by manufacturer for operation of system.
- F. Connect water, fuel, breeching, and exhaust vent as shown on Drawings. Combustion air shall come from within Boiler Room from combustion air louver...
- G. Furnish to manufacturer's wiring diagram and electrical requirements for installation of field wiring required for hot water boilers.
- H. Flush and clean hot water boilers upon completion of installation in accordance with manufacturer's startup instructions.
- I. Provide boiler manufacturer recommended manifold pipe and fittings from each boiler to nearest floor drain or as indicated.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

- 1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite for mandays indicated, travel time excluded, for assistance during equipment startup, and training of Owner's personnel for equipment operation. Include:
 - a. 1 man-day for Installation Services.
 - b. 1 man-day for Instructional Services.
- 2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system related areas. See Section 01 60 10.

B. Testing:

- 1. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- 2. Hydrostatically test assembled boiler and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
- 3. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boiler, boiler piping, observation of hydrostatic testing and certification of completed boiler units. Obtain certification for completed boiler units, deliver to Owner and obtain a receipt.

END OF SECTION

SECTION 23 64 23

AIR COOLED, SCROLL WATER CHILLER

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Performance Requirements:

1. Factory run test unit under full load operating conditions to check performance for capacity, efficiency, vibration, operating control, and safety cutouts in accordance with the requirements of ARI 550/590. Submit independently certified test data to Owner prior to shipment of unit.
2. If equipment fails to perform within allowable tolerances, manufacturer will be allowed to make necessary equipment modifications and retest as required. If modifications fail to achieve submitted performance, manufacturer agrees to following penalties.
 - a. Capacity Test: For each ton below 95% design capacity, \$500/ton will be assessed against Contract Price of machine, and fully refunded to Owner.
 - b. Power Consumption Test: Power consumption penalty shall be based on tolerances set forth in ARI 550, and shall be calculated using following formula:

$$Penalty = [Measured\ KW - (Measured\ Tons \times Allowable\ KW/T)] \times \$1,000/KW$$

where:

$$Allowable\ KW/T = 1.05 \times design\ KW/T$$

3. Total Performance Penalty: Total performance penalty shall equal sum of capacity penalty and power consumption penalty.

1.02 SUBMITTALS:

A. Product Data:

1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
2. Condenser pressure drop.
3. Cooler pressure drop.

4. Weights (shipping, installed, and operating)
5. Furnished Accessories.
6. Installation and startup instructions.
7. Performance at AHRI standard conditions and at conditions indicated.
8. Performance at AHRI standard unloading conditions.
9. Minimum evaporator flow rate.
10. Refrigerant capacity of water chiller.
11. Oil capacity of water chiller.
12. Fluid capacity of evaporator.
13. Characteristics of safety relief valves.
14. Force and moment capacity of each piping connection.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

C. Operations and Maintenance Data (O&M):

1. Operating instructions, maintenance procedures including lubrication instructions, control motor and drive replacement, and spare parts list.

1.03 SUBMITTALS

A. Coordination Drawings:

1. Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.

- b. Piping roughing-in requirements.
 - c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
 - d. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
- 2. Coordination drawings showing plan, section and elevation views
- 3. Each view to show screened background with the following:
 - a. Column grids, beams, columns, and concrete housekeeping pads.
 - b. Layout with walls, floors, and roofs, including each room name and number.
 - c. Equipment and products of other trades that are located in vicinity of chillers and part of final installation, such as plumbing systems.
- B. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturers.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Installation instructions.
- D. Source quality-control reports.
- E. Startup service reports.
- F. Sample Warranty: For special warranty.
- 1.04 CLOSEOUT SUBMITTALS
 - A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
 - B. Spare Parts List: Recommended spare parts list with quantity for each.
 - C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.05 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
- B. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
- C. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
- D. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
- E. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.
- F. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.06 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.07 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.08 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.09 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.10 WARRANTY:

- A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

- a. Complete chiller including refrigerant and oil charge.

- b. Complete compressor and drive assembly including refrigerant and oil charge.
 - c. Refrigerant and oil charge.
 - d. Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.
 - e. Parts and labor.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Carrier Corporation, Division of United Technologies, Inc.
- B. Trane Company.
- C. Or equal.

2.02 UNIT DESCRIPTION

- A. Provide and install as shown on the plans factory-assembled, factory-charged air-cooled scroll compressor packaged chillers in the quantity specified. Each chiller shall consist of hermetic tandem or triple scroll compressor sets, brazed plate evaporator, air-cooled condenser section, microprocessor-based control system and all components necessary for controlled unit operation
- B. Each chiller shall be factory run-tested with water to verify full-load operation. Operating controls and refrigerant charge shall be verified for proper operation and optimum performance. Any deviation shall be remedied prior to shipment and the unit retested if necessary to confirm repairs or adjustments.

2.03 PERFORMANCE REQUIREMENTS:

- A. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.5.
- B. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

- C. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
 - 1. Allowable Capacity Tolerance: Zero percent.
 - 2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
 - 3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.
- D. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.
- E. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
- F. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- G. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- H. Comply with NFPA 70.
- I. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.
- J. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
 - 2. See drawings for equipment served by backup power systems.
 - 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- K. Outdoor Installations:
 - 1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.
 - 2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period.

2.04 CAPACITIES AND CHARACTERISTICS:

- A. Refer to equipment schedules on drawings for performance and physical characteristics.

2.05 CHILLER COMPONENTS

A. Compressor

1. The compressors shall be sealed hermetic, scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads. The 20 – 90 ton compressors shall be equipped with an internal module providing compressor protection and communication capability.

B. Evaporator

1. The evaporator shall be a compact, high efficiency, dual circuit, brazed plate-to-plate type heat exchanger consisting of parallel stainless steel plates.
 - a. The evaporator shall be protected with an electric resistance heater (heat trace tape) and insulated with 3/4" (19mm) thick closed-cell polyurethane insulation. This combination shall provide freeze protection down to -20°F ambient air temperature.
 - b. The water-side working pressure shall be a minimum of 653 psig. Vent and drain connections shall be provided in the inlet and outlet chilled water piping by the installing contractor. Evaporators shall be designed and constructed according to, and listed by, Underwriters Laboratories (UL).

C. Condenser

1. The condenser coils shall consist of 3/8 inch (10mm) seamless copper tubes mechanically bonded into plate type fins. The fins shall have full drawn collars to completely cover the tubes. A subcooling coil shall be an integral part of the main condenser coil.
 - a. Condenser fans shall be propeller type arranged for vertical air discharge and individually driven by direct drive fan motors. Each fan shall be in its own compartment to eliminate cross flow of condenser air during fan cycling and shall be equipped with a heavy-gauge vinyl coated fan guard.
 - b. Fan motors shall be weather protected, three-phase, direct-drive, 1140 rpm, TEAO type with permanently lubricated ball bearings and inherent overload protection. External coils shall have wire mesh protective guards.
2. Condenser coils shall be rippled aluminum fins.

D. Refrigerant Circuit

1. Each of the two refrigerant circuits shall include a replaceable-core refrigerant filter-drier, sight glass with moisture indicator, liquid line solenoid valve (no exceptions), thermal expansion valve, and insulated suction line.

E. Construction

1. Unit casing and all structural members and rails shall be fabricated of steel and painted to meet ASTM B117, 500-hour salt spray test.
2. Upper condenser coil section of unit shall have protective, 12 GA, PVC-coated, wire grille guards.

F. Control System

1. A centrally located weatherproof control panel shall contain the field power connection points, control interlock terminals, and control system. Power and starting components shall include factory circuit breaker of fan motors and control circuit, individual contactors for each fan motor, solid-state compressor three-phase motor overload protection, inherent fan motor overload protection and two power blocks (one per circuit) for connection to remote, contractor supplied disconnect switches. Hinged access doors shall be lockable. Barrier panels or separate enclosures are required to protect against accidental contact with line voltage when accessing the control system.
2. Shall include optional single-point connection to a non-fused disconnect switch with through-the-door handle and compressor circuit breakers.

G. Unit Controller

1. An advanced DDC microprocessor unit controller with a 4-line by 20-character liquid crystal display provides the operating and protection functions. The controller shall take pre-emptive limiting action in case of high discharge pressure or low evaporator pressure. The controller shall contain the following features as a minimum:
 - a. Equipment Protection
 - (1) The unit shall be protected in two ways: (1) by alarms that shut the unit down and require manual reset to restore unit operation and (2) by limit alarms that reduce unit operation in response to some out-of-limit condition. Shut down alarms shall activate an alarm signal.
 - b. Shutdown Alarms
 - (1) No evaporator water flow (auto-restart)
 - (2) Sensor failures

- (3) Low evaporator pressure
- (4) Evaporator freeze protection
- (5) High condenser pressure
- (6) Outside ambient temperature (auto-restart)
- (7) Motor protection system
- (8) Phase voltage protection (Optional)
- c. Limit Alarms
 - (1) Condenser pressure stage down, unloads unit at high discharge pressures.
 - (2) Low ambient lockout, shuts off unit at low ambient temperatures.
 - (3) Low evaporator pressure hold, holds stage #1 until pressure rises.
 - (4) Low evaporator pressure unload, shuts off one compressor.
- d. Unit Enable Selection
 - (1) Enable unit operation from either local keypad, digital input or BAS
- e. Unit Mode Selection
 - (1) Selects standard cooling, ice, glycol, or test operation mode
- f. Analog Inputs:
 - (1) Reset of leaving water temperature, 4-20 mA
 - (2) Current limit
- g. Digital Inputs
 - (1) Unit off switch
 - (2) Remote start/stop
 - (3) Flow switch
 - (4) Ice mode switch, converts operation and setpoints for ice production
 - (5) Motor protection

- h. Digital Outputs
 - (1) Shutdown alarm; field wired, activates on an alarm condition, off when an alarm is cleared
 - (2) Evaporator [ump field wired, starts pump when unit is set to start
- i. Condenser fan control - The unit controller shall provide control of condenser fans based on compressor discharge pressure
- j. Building Automation System (BAS) Interface
 - (1) Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARK ® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier.
 - (2) The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.
 - (3) All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.

2.06 OPTIONS AND ACCESSORIES

A. The following options are to be included:

- 1. High Ambient Control Panel for operation from 105°F up to 125°F ambient temperatures
- 2. BAS interface module to provide interface with the BACnet Ethernet protocol.
- 3. Unitech Sound Attenuator
- 4. The following accessories, if selected, are to be included:
 - a. Evaporator inlet strainer, 40-mesh with extension pipe and Victaulic couplings

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive chillers for compliance with installation tolerances and other conditions affecting chiller performance. Examine proposed route of moving chillers into place and verify that it is free of interferences. Verify piping rough in locations. Verify branch circuit wiring suitability. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install and anchor chillers plumb and level.
- B. Maintain manufacturer's recommended clearances for service and maintenance.
- C. Install piping connections, maintaining clearances for service and maintenance.
- D. Install flanged or union connections at chillers.
- E. Install shutoff valves at chiller inlet and outlet connections.
- F. Install a field supplied strainer in the chilled water return line at the evaporator inlet; 40-mesh on units with brazed-plate evaporators or 20-mesh on shell-and-tube evaporators.
- G. Install electrical devices furnished loose by manufacturer, including remote flow switches and remote chiller control panel. Furnish copy of manufacturer's wiring diagram submittal to electrical Installer.

3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services:
 - 1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite or classroom designated by Owner for mandays indicated, travel time excluded, for assistance during plant construction, plant startup, and training of Owner's personnel for plant operation. Include:
 - a. 1 manday for Installation Services.
 - b. 1/2 manday for Instructional Services.
 - 2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system related areas. See Section 01 60 00.
 - 3. Provide services of factory authorized service representative to supervise field assembly of components and installation of chillers, including piping and electrical connections, and to report results in writing.

4. Provide factory authorized service representative to start chillers and to demonstrate and train Owner's maintenance personnel as specified below.
 - a. Test and adjust chiller controls and safeties. Lubricate rotating parts. Verify that motor amperage conforms to manufacturer's data.
 - b. Install proper charge of refrigerant and oil.
 - c. Start chiller and verify performance. Demonstrate operation to Owner.
 - d. Train Owner's maintenance personnel on procedures and schedules for startup, shutdown, troubleshooting, servicing, and preventive maintenance.

3.04 CLEANING

- A. Clean units using materials and methods recommended by manufacturer.
- B. Clean finishes to remove dust and dirt.
- C. Touch up scratches on unfinished surfaces to restore corrosion resistance.
- D. Touch up scratches on finished surfaces to restore finish.

END OF SECTION

SECTION 23 73 13

INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following as indicated and in compliance with Contract Documents.
 - 1. Casings
 - 2. Fans, drives, and motors
 - 3. Coils
 - 4. Air filtration
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
 - 1. 260: Sound Rating of Ducted Air Moving and Conditioning Equipment
 - 2. 410: Forced-Circulation Air-Cooling and Air-Heating Coils
 - 3. 430: Performance Rating of Central Station Air-Handling Units
- C. Air Movement and Control Association Inc. (AMCA):
 - 1. 210: Laboratory Methods of Testing Fans for Rating
 - 2. 300: Reverberant Room Method for Sound Testing of Fans
 - 3. 99-2408: Operating Limits for Centrifugal Fans
- D. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 33: Methods of Testing Forced-Circulation Air-Cooling and Air-Heating Coils
 - 2. 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
 - 3. 62.1: Ventilation for Acceptable Indoor Air Quality
 - 4. 90.1: Heating, Ventilating, and Air Conditioning
 - 5. 111: Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems

Indoor, Semi-Custom Air-Handling Units

Section No. 23 73 13-1

E. ASTM International (ASTM):

1. A36: Standard Specification for Carbon Structural Steel
2. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
3. A568: Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements
4. A653: Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
5. B88: Standard Specification for Seamless Copper Water Tube
6. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
7. C1071: Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
8. E84: Standard Test Method for Surface Burning Characteristics of Building Materials

F. National Electrical Contractors Association (NECA):

1. 1: Standard for Good Workmanship in Electrical Construction

G. National Electrical Manufacturers Association (NEMA):

1. MG 1: Motors and Generators

H. National Fire Protection Association (NFPA):

1. 70: National Electrical Code.
2. 90A: Standards for the Installation of Air-Conditioning and Ventilating Systems

I. Sheet Metal and Air Conditioning Contractors National Association (SMANCA):

1. HVAC Duct Construction Standards

J. Underwriters' Laboratories, Inc. (UL):

1. 181: Standard for Safety Factory-Made Air Ducts and Connectors
2. 900: Standard for Safety Air Filter Units
3. 1995: Standard for Safety Heating and Cooling Equipment

1.02 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data: For each air-handling unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - 6. Include certified coil-performance ratings with system operating conditions indicated.
 - 7. Include filters with performance characteristics.
 - 8. Include dampers, including housings, linkages, and operators.
- C. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
 - 4. Include diagrams for power, signal, and control wiring.

- D. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - E. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
 - F. Delegated Design Submittals: For each device, equipment or appurtenance provide written certification from Professional Engineer licensed in the State of Utah stating that supports systems and anchorage for equipment have been designed according to the requirements of Section 1613 of the building codes of Utah, Salt Lake City and ASCE/SEI 7, and in accordance with Specification 01 41 20. Submit calculations stamped by a Professional Engineer licensed in the State of Utah for support systems and anchorage for wind, seismic, and all other pertinent loads.
 - G. Source quality-control reports.
 - H. Startup service reports.
 - I. Field quality-control reports.
 - J. Sample Warranty: For manufacturer's warranty.
 - K. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.
 - L. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set for each air-handling unit.
 - 2. Fan Belts: One set for each air-handling unit fan.
- 1.03 SUSTAINABLE DESIGN:
- A. Comply with the requirements specified in Section 01 81 13.01.
- 1.04 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.05 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
- 1.06 DELIVERY STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

1.07 WARRANTY:

- A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 2 years from date of Substantial Completion on internal functional components and 5 years from date of Substantial Completion on the casing.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 43 00, to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 4-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.005 inch/inch of panel span.
- G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at +/- 8 inch wg.
- H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Design criteria: Refer to the requirements of Section 01 41 20.

2.02 CAPACITIES AND CHARACTERISTICS:

- A. Refer to equipment schedules on drawings for performance and physical characteristics.

2.03 MANUFACTURERS:

- A. Carrier
- B. Trane
- C. Or equal

2.04 CASINGS:

A. General Fabrication Requirements for Casings;

- 1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
- 2. Joints: Sheet metal screws or pop rivets.
- 3. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.
- 4. Base Rail:
 - a. Material: Galvanized steel.
 - b. Height: 4 inches.

B. Double-Wall Construction:

- 1. Outside Casing Wall:
 - a. Standard Material, Galvanized Steel: Minimum 18 gauge thick unless noted otherwise on the equipment schedule.
 - b. Alternate Material, Aluminum: Minimum 16 gauge thick when required per equipment schedule.
 - c. Alternate Material, Stainless Steel: Minimum 18 gauge thick when required per equipment schedule.
- 2. Inside Casing Wall and Floor Plate:
 - a. Standard Material, Solid galvanized Steel: Minimum 18 gauge thick unless noted otherwise on the equipment schedule.
 - b. Alternate Material, Solid aluminum: Minimum 16 gauge thick when required per equipment schedule.
 - c. Alternate Material, Solid stainless Steel: Minimum 18 gauge thick when required per equipment schedule.

3. Floor Plate: G90 galvanized steel, minimum 18 gauge thick.
- C. Casing Insulation:
1. Materials: Injected polyurethane foam insulation.
 2. Casing Panel R-Value: Minimum R-13.
 3. Insulation Thickness: 2 inches .
 4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
- D. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- E. Panels, Doors, and Windows:
1. Panels:
 - a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components.
 2. Doors:
 - a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing complete with viewing window.
 - b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 72 inches.

3. Locations and Applications:
 - a. Fan Section: Doors.
 - b. Coil Section: Panels.
 - c. Access Sections Immediately Upstream and Downstream of Coil Sections: Doors.
 - d. Filter Section: Doors large enough to allow periodic removal and installation of filters.
 - e. Access Sections Immediately Upstream and Downstream of Filter Sections: Doors.

F. Condensate Drain Pans:

1. Construction:
 - a. Single-wall, dual sloped, stainless-steel sheet.
2. Drain Connection:
 - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
3. Slope: Slope is to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches deep.
7. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.05 FANS, DRIVES, AND MOTORS:

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.
 1. Shafts: With field-adjustable alignment.

- a. Turned, ground, and polished hot-rolled steel with keyway.
- 2. Shaft Bearings:
 - a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.
- 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
- 4. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
- 5. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel hub swaged to backplate and fastened to shaft with setscrews.
- 6. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- 7. Mounting: For internal vibration isolation and seismic control. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
- 8. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch- wide by 0.028-inch-thick, galvanized-steel sheet.
 - a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Motors:

- 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
- 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- 3. Enclosure Type: Totally enclosed, fan cooled.

4. Unusual Service Conditions:
 - a. Altitude: 4,500 feet above sea level.
5. Efficiency: Premium Efficient motors as defined in NEMA MG 1.
6. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
7. Provide full voltage non-reversing motor starters.
8. Mount unit-mounted disconnect switches on exterior of unit.

D. Variable-Frequency Motor Controller: Comply with Section 26 29 23.

2.06 COILS:

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Heating Coils:

1. Hot-Water Coils: Self-draining.
 - a. Piping Connections: Same end of coil and
 - (1) Threaded if pipe connection is NPS 2" or less.
 - (2) Flanged if pipe connection is NPS 2-1/2" or greater.
 - b. Tube Material: Copper.
 - c. Fin Type: Plate.
 - d. Fin Material: Aluminum.
 - e. Fin Spacing: Maximum 12 fins per inch.
 - f. Fin and Tube Joint: Mechanical bond.
 - g. Headers:
 - (1) Seamless copper tube with brazed joints, prime coated.

- (2) Provide insulated cover to conceal exposed outside casings of headers.
 - h. Frames: Channel frame, 0.052-inch- thick, galvanized steel.
 - i. Coil Working-Pressure Ratings: 200 psig, 325 degrees F.
 - j. Coating: Corrosion-resistant coating. No exposed copper.

C. Cooling Coils:

- 1. Chilled-Water Coil: Self-draining.
 - a. Piping Connections: Same end of coil and
 - (1) Threaded if pipe connection is NPS 2" or less.
 - (2) Flanged if pipe connection is NPS 2-1/2" or greater
 - b. Tube Material: Copper.
 - c. Fin Type: Plate.
 - d. Fin Material: Aluminum.
 - e. Fin Spacing: Maximum 12 fins per inch.
 - f. Fin and Tube Joint: Mechanical bond.
 - g. Headers:
 - (1) Seamless copper tube with brazed joints, prime coated.
 - (2) Provide insulated cover to conceal exposed outside casings of headers.
 - h. Frames: Channel frame, 0.052-inch- thick, galvanized steel.
 - i. Coil Working-Pressure Ratings: 200 psig, 325 degrees F.
 - j. Coating: Corrosion-resistant coating. No exposed copper.

2.07 AIR FILTRATION:

- A. Particulate air filtration is specified in Section 23 41 00.
- B. Panel Filters:
 - 1. Description: Pleated factory-fabricated, self-supported disposable air filters with holding frames.
 - 2. Filter Unit Class: UL 900.

3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: High wet-strength beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized track.
 - a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.08 MATERIALS:

A. Steel:

1. ASTM A36 for carbon structural steel
2. ASTM A568 for steel sheet

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240 for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653

D. Aluminum: ASTM B209

E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:
 - a. ASTM B117 for salt spray
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m)
 - c. ASTM B3359 for cross hatch adhesion of 5B
2. Application: Immersion
3. Thickness: 1 mil

4. Gloss: Minimum gloss of 60 on a 60-degree meter

2.09 SOURCE QUALITY CONTROL:

- A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.
- B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
- C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

- A. Equipment Mounting:
 1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 03 30 00.
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 23 05 48.
 3. The installation is to meet the seismic restraint requirements as stated in Section 01 41 20 and Section 23 05 48.
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

- D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 33 00.

3.03 PIPING CONNECTIONS:

- A. Piping installation requirements are specified in other sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 23 21 13 and Section 23 21 16. Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.04 ELECTRICAL CONNECTIONS:

- A. Ground equipment according to Section 26 05 26.
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 05 53.

3.05 CONTROL CONNECTIONS:

- A. Install control and electrical power wiring to field-mounted control devices.

3.06 STARTUP SERVICE:

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 7. Comb coil fins for parallel orientation.
 8. Install new, clean filters.
 9. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
 2. Measure and record motor electrical values for voltage and amperage.
 3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.07 ADJUSTING:

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 23 05 93 for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project for this purpose.

3.08 CLEANING:

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.09 FIELD QUALITY CONTROL:

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Leak Test: After installation, fill water, and test coils and connections for leaks.
 - 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.10 DEMONSTRATION:

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units. Provide up to two full days of training for this purpose.

3.11 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 81 26

SPLIT-SYSTEM HEAT PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section includes split-system heat pump units consisting of separate evaporator-fan and compressor-condenser components.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.

1.04 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.07 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Store equipment in a clean dry location. Protect from damage and moisture. Follow manufacture requirements for handling and rigging.

1.09 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

- a. For Compressor: Five year(s) from date of Substantial Completion.
- b. For Parts: Five year(s) from date of Substantial Completion.
- c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the following:
 1. Mitsubishi Electric & Electronics USA, Inc
 2. Carrier Corporation; a unit of United Technologies Corp
 3. Daikin Air Conditioning

4. Friedrich Air Conditioning Company
5. Mitsubishi Electric & Electronics USA, Inc
6. SANYO North America Corporation
7. LG

2.02 INDOOR UNITS (5 TONS OR LESS, CEILING CASSETTE, HEAT PUMP)

- A. Size and capacity as indicated on the drawings.
- B. Ceiling Cassette, Evaporator-Fan Components:
 1. Cabinet: Enameled steel with a four-way grille fixed to bottom of cabinet allowing two, three or four-way blow. The grille shall allow the unit to be serviceable from the bottom, without the need for an access panel.
 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
 3. Fan: Direct drive, centrifugal.
 4. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Enclosure Type: Totally enclosed, fan cooled.
 - c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - d. Mount unit-mounted disconnect switches on exterior of unit.
 5. Condensate Drain Pans:
 - a. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - b. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan. Provide a factory-installed drain pan sensor to provide protection against drain pan overflow by sensing a high condensate level in the drain pan. Should this occur the control shuts down the indoor unit before an overflow can occur.

2.03 OUTDOOR UNITS (5 TONS OR LESS, HEAT PUMP)

- A. Size and capacity as indicated on the drawings.
- B. Air-Cooled, Compressor-Condenser Components:
 - 1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
 - 2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Variable-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant: R-410A.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
 - 3. Fan: Aluminum-propeller type, directly connected to motor.
 - 4. Motor: Permanently lubricated, with integral thermal-overload protection.
 - 5. Low Ambient Kit: Permits cooling operation down to 0 deg F.
 - 6. The outdoor unit shall be capable of guaranteed operation in heating mode down to -13°F ambient temperatures and cooling mode up to 115°F without additional restrictions on line length & vertical separation beyond those published in respective product catalogs.

2.04 ACCESSORIES

- A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- C. Drain Hose: For condensate.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install units' level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Equipment Mounting:
 - 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.03 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.04 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 23 82 19

FAN AND BLOWER COIL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:

- 1. Fan and blower coil units.

1.03 SUBMITTALS

- A. Product Data: For each type of product.

- 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

- B. Sustainable Design:

- 1. Comply with requirements specified in Section 01 81 13.01.

- C. Shop Drawings:

- 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Structural members to which fan coil units will be attached.
 - 4. Method of attaching hangers to building structure.

- D. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.

- 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control reports.

1.04 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish 2 spare filters for each filter installed.

2. Fan Belts: Furnish 2 spare fan belts for each unit installed.

1.05 QUALITY ASSURANCE

- A. Comply with NFPA 70.

- B. Comply with the requirements specified in Section 01 43 00.

- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.06 COORDINATION

- A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

- B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.07 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.02 FAN AND BLOWER COIL UNITS

A. Manufacturers:

1. Trane
2. Carrier
3. Daikin
4. Or equal.

B. Fabrication:

1. Tubes: 1/2 inch OD seamless copper or brass arranged in parallel or staggered pattern, expanded into fins, brazed joints.
2. Fins: Aluminum or copper continuous plate type with full fin collars or individual helical spiral finned tube type wound under tension.

C. Water Coils:

1. Headers: Cast iron with tubes expanded into header, seamless copper tube with silver brazed joints, or prime coated steel pipe with brazed joints.
2. Leak Testing: Air test under water to 200 psig for working pressure of 200 psig and 200 degrees F.
3. Configuration: Self draining circuitry, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.

D. Casings:

1. Heavy-gauge galvanized steel, insulated with one-inch, 1-1/2 lb density fiberglass fire resistant and odorless glass fiber material to provide thermal and acoustical insulation.
2. Coil access panels are located on the sides and allow easy removal of the internal coils and drain pan.

E. Fans:

1. DWDI (double width double inlet) forward curved centrifugal blower type.
2. Fans are dynamically balanced.

F. Filters:

Two inch pleated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install fan and blower coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.04 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate heating and cooling elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.05 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project for this purpose.

3.06 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

3.07 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 23 82 39

UNIT HEATERS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide unit heaters as indicated and in compliance with Contract Documents.
 - 1. Electric unit heaters.
 - 2. Hot water unit heaters.

1.02 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data:
 - 1. Submit manufacturer's instructions, printed product literature and data sheets for unit heaters and include product characteristics, performance criteria, physical size, finish and limitations.
- C. Manufacturer's Instructions: provide to indicate special handling criteria, installation sequence and cleaning procedures.
- D. Delegated Design Submittals: For each device, equipment or appurtenance provide written certification from Professional Engineer licensed in the State of Utah stating that supports systems and anchorage for equipment have been designed according to the requirements of Section 1613 of the building codes of Utah, Provo and ASCE/SEI 7, and in accordance with Specification 01 41 20. Submit calculations stamped by a Professional Engineer licensed in the State of Utah for support systems and anchorage for wind, seismic, and all other pertinent loads.
- E. Closeout Submittals:
 - 1. Submit in accordance with Section 01 77 00.
 - 2. Operation and Maintenance Data: Submit operation and maintenance data for unit heaters for incorporation into manual.

1.03 SUSTAINABLE DESIGN:

- A. Comply with the requirements specified in Section 01 81 13.01.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Deliver, store and handle materials in accordance with Section 01 61 00 and with manufacturer's written instructions.
- C. Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- D. Storage and Handling Requirements:
 - 1. Store materials off ground indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - 2. Store and protect unit heaters from nicks, scratches, and blemishes.
 - 3. Replace defective or damaged materials with new.

PART 2 - PRODUCTS

2.01 ELECTRIC UNIT HEATERS:

- A. Unit heater: UL listed for wall or ceiling mounting. horizontal discharge complete with adjustable louvers finished to match cabinet.
- B. Capacity and power requirements as per Equipment Schedules on Drawings.
- C. Fan type unit heaters with built-in contactors, control circuit transformers, high-heat limit protection, and fan-delay switches.
- D. Fan motor: Totally enclosed, permanently lubricated with resilient mount.
 - 1. Built-in fan motor thermal overload protection.
- E. Hangers: As indicated.

- F. Elements: Nickel-chromium resistance wire surrounded with magnesium oxide and sheathed in steel spiral finned tubes.
- G. Cabinet: 18 gauge steel
 - 1. Epoxy/polyester powder coat finish.
- H. Acceptable manufacturers:
 - 1. Modine
 - 2. Trane
 - 3. Or equal

2.02 HOT WATER UNIT HEATERS:

- A. Unit heater: UL listed for wall or ceiling mounting. horizontal discharge complete with adjustable louvers finished to match cabinet.
- B. Capacity and power requirements as per Equipment Schedules on Drawings.
- C. Propeller fan type unit heaters with built-in contactors, control circuit transformers, high-heat limit protection, fan-delay switches, and aquastat.
- D. Fan motor: Totally enclosed, permanently lubricated with resilient mount.
 - 1. Built-in fan motor thermal overload protection.
- E. Coils: Seamless copper tubing, 0.025 inch minimum wall thickness, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
- F. Cabinet: 18 gauge steel
 - 1. Enamel coat finish.
 - 2. Threaded pipe connections for hanger rods.
 - 3. Fan guard.
- G. Testing: Factory test to 200 psig hydrostatic pressure and to 300 psig with air under water.
- H. Acceptable manufacturers:
 - 1. Modine
 - 2. Trane
 - 3. Or equal

2.03 CONTROLS:

- A. Wall mounted thermostat and support controls.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Suspend unit heaters from ceiling or mount on wall as indicated.
- B. Make power and control connections.
- C. Make piping connections for hot water unit heaters.

3.02 FIELD QUALITY CONTROL:

- A. Test cut-out protection when air movement is obstructed.
- B. Test fan delay switch to assure dissipation of heat after element shut down.
- C. Test unit cut-off when fan motor overload protection has operated.
- D. Ensure heaters and controls operate correctly.

3.03 CLEANING:

- A. Progress Cleaning: clean in accordance with Section 01 74 23.
 - 1. Leave work area clean at end of each day.

3.04 PROTECTION:

- A. Protect installed products and components from damage during construction.
- B. Repair damage to adjacent materials caused by unit heaters installation.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 10

ELECTRICAL WORK – GENERAL

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide complete and operational systems for both normal and standby electric power systems, normal and emergency lighting systems, grounding systems and other specified systems, including the installation and wiring of miscellaneous equipment and devices. Perform all work and testing as indicated and in compliance with Contract Documents.
 - 1. Provide conduit, wiring and connections for power, control, lighting, instrumentation and alarms for equipment furnished by others unless otherwise specified and indicated.
 - 2. Provide temporary circuits, overcurrent devices, conduit and wiring, and other equipment required during construction and change-over from existing to proposed electric system. Perform work at the convenience of the Owner.
 - 3. Raceways supports and equipment anchoring shall be provided as specified in the Division 26 sections which form a part of the Contract Documents.
 - 4. The equipment enclosure classification of the plant areas are indicated on the drawings. Provide all equipment, devices and material meeting the requirements for these area classifications unless otherwise noted or specified.
 - 5. Review the electrical underground system and the civil yard piping. Install the electrical underground system in a manner that avoids conflicts with manholes, catch basins, etc. provided under other Divisions of the specifications

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).

1.03 SEQUENCING AND SCHEDULING

- A. Coordinate electrical equipment installation with other building components.
- B. Arrange for chases, slots and openings in the building structures during the progress of construction to allow for the electrical installation.
- C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

- D. Sequence, coordinate and integrate the installation of electrical materials and equipment for efficient flow of the work.
- E. Coordinate the installation of large equipment prior to closing in the building.

1.04 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.
- B. Install electrical work in conformance with latest rules and requirements of National Fire Protection Association Standard No. 70 (National Electrical Code) and in accordance with requirements of State and Local Codes.

1.05 QUALIFICATIONS OF ELECTRICAL SUBCONTRACTOR

- A. The Electrical Subcontractor shall have been engaged in work of a similar nature to this contract for the past 5 years.
- B. The Electrical Subcontractor shall have a minimum of five projects of equal or greater size with the type of equipment specified under this project.

1.06 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00 “Submittals”:
 - 1. The following defines a minimum for all Division 26 shop drawing and data submittals:
 - a. Submit shop drawings delineated by specification number with all information for one piece of equipment provided as one package.
 - b. Provide PDF versions with electronic bookmarks.
 - c. Provide with a copy of the specification section with exceptions noted including explanation.
 - d. Partial submittals will be returned without action.
 - e. Submit bills of material: Include a numbered list of all components, with manufacturer's name, catalog number, rating, and other identification. Place item number or similar identification on all other drawings where item appears.
 - f. Submittal shall include:
 - (1) Manufacturer’s drawings
 - (2) Panel layout

- (3) Equipment layout
 - (4) Schematic diagram
 - (5) One line diagram
 - (6) Control sequence diagrams
 - (7) Interconnection diagrams
 - (8) Wiring diagrams
 - (9) Catalog data
- g. Submit only completed drawings showing all local and remote devices associated with each item.
 - h. Mark shop drawings and data submitted showing only items applicable to specific contract.
 - i. Where additions and modifications are made to existing equipment, provide drawings which include both retained existing equipment and new work.
 - j. Submit time-current characteristic curves for all submitted protection devices such as circuit breakers and fuses.
 - k. Submit other documentary or descriptive information as required for each assembly to demonstrate compliance with the applicable contract documents.
2. Shop drawings and data are required for the following list:
- a. Conduit and Fittings
 - b. Wire and Cable
 - c. Wiring Devices
 - d. Transformers
 - e. Low Voltage Switchboards
 - f. Low Voltage Switchgear
 - g. Manholes, Handholes, and Associated Equipment and Devices
 - h. Grounding Equipment and Devices
 - i. Panelboards

- j. Lighting Fixtures and Accessories
 - k. Lighting Control Panels
 - l. Lightning Protection System
 - m. Intrusion Alarm System
 - n. Fire Alarm System
 - o. Card Access System
 - p. Surveillance System
 - q. Control Stations
 - r. Enclosures
 - s. Control Panels
 - t. Safety Switches
 - u. Mats
 - v. 600 Volt Motor Control Centers and Motor Controls
 - w. Switchboards
 - x. Field Acceptance Test Reports
 - y. Record Drawings
3. Submit instruction manuals for installation, operation, and maintenance of equipment, and parts list for equipment listed below. Specifically mark standard publications forming a part of this contract. Cross out, blank out, or otherwise delete non-applicable items. Submittals which do not clearly indicate items and features provided shall be rejected.
- a. Low Voltage Switchgear
 - b. Lightning Protection System
 - c. Intrusion Alarm System
 - d. Fire Alarm System
 - e. Card Access System
 - f. Surveillance System

g. 600 Volt Motor Control Centers

h. Switchboards

1.07 NAMEPLATES AND LABELING

- A. Provide nameplates and labels as specified in Section 26 05 53 “Electrical Identification”.

1.08 INTERFERENCE AND ERRONEOUS LOCATIONS

- A. Locations of electrical equipment, devices, outlets, and similar items, as indicated, are approximate only. Exact locations shall be determined during construction.
- B. Verify in field, all data and final locations of work installed under other sections of specifications, required for placing of electrical work.
- C. In case of interference with other work or erroneous locations with respect to equipment or structures, furnish all labor and materials to complete the work.

1.09 SEISMIC DESIGN REQUIREMENTS

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20 and in Division 26.
- B. All raceways and equipment installed under Division 26 shall use earthquake resistant supporting systems as specifically required in each applicable section.

1.10 APPROVAL AND MARKING EQUIPMENT

- A. Ensure that devices and materials are listed and/or labeled by UL, wherever standards have been established by that organization. Where a UL listing is not available for equipment, submit certified test reports of a Nationally Recognized Testing Laboratory (NRTL), approved by the local inspecting authority, indicating that equipment is in conformance with local code requirements or any other applicable requirements. Tests and inspections for approval of equipment shall be performed at no additional cost to Owner.
- B. Clearly mark equipment, devices and material with name or trademark of manufacturer and rating in volts and amperes and other pertinent information on a nameplate.

1.11 ELECTRIC SERVICE

- A. Electrical power system for the facility operates at 277/480-volt, 3-phase, 4-wire, 60 Hertz.
 - 1. Provide electrical low voltage distribution system that operates on 208/120-volt, 3-phase, 4-wire, 60 Hertz obtained from the power system by dry-type transformer(s).

- B. Earth and rock excavation, backfill, concrete masonry, concrete reinforcement, and construction joints required for electrical work is included under this section and shall conform to requirements specified under applicable sections of Contract for General Construction.

1.12 EQUIPMENT SPECIFIED ELSEWHERE

- A. Certain items of control equipment and other equipment are indicated on electrical drawings for connection, but are specified in other sections pertaining to plumbing, heating, ventilating and air conditioning, mechanical process, instrumentation, etc. Such items are not furnished as part of electrical work.

1.13 INCOMING SERVICE

- A. Contact the following organization for coordinating the incoming power requirements for the project:

Provo Power
Jonathan Saluone
(801) 852-6831

- B. The organization identified above will furnish and install:

1. Pad-mounted transformers and sectionalizer cabinet(s).
2. Primary cable.
3. Connection of all primary cables.
4. Metering equipment.

- C. The contractor shall provide the following in accordance with the contract documents:

1. Concrete pad for transformers and sectionalizer cabinet(s).
2. Primary and secondary ductlines.
3. Secondary cables of sufficient length for termination at the transformer.
4. Connection of all secondary cables.
5. Grounding at transformer pads.
6. Provide cabinets for metering equipment and current transformers.

- D. The final, complete installation shall comply with all state and local statutory requirements having jurisdiction. The Contractor shall arrange for all necessary permits, pay all fees and arrange for all required inspections by local authorities. In general, all work shall comply

with the requirements of the National Electrical Code, all state codes and the codes and ordinances of the city or town in which the work is to be done.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 PROTECTION OF ELECTRICAL EQUIPMENT

- A. Store equipment in compliance with manufacturer's recommendations and as specified herein.
- B. Protect electrical equipment from the weather, especially from water dripping or splashing upon it, at all times during shipment, storage, and construction.
- C. Do not store equipment outdoors.
- D. Where equipment is installed or stored in moist areas, or unheated buildings, provide acceptable means to prevent moisture damage. Provide uniformly distributed source of heat in electrical equipment to prevent condensation and damage to electrical insulation systems.

3.02 DEFECTIVE OR DAMAGED EQUIPMENT

- A. Damaged equipment shall not be used. Equipment damaged in shipment, storage, installation or through other means shall be replaced without additional cost to the Owner.
- B. All equipment showing signs of water damage shall be rejected regardless of dielectric test results.
- C. All electrical equipment is considered "in storage" regardless of location until first energized. Manufacturer's recommendations for storage precautions, conditions and care shall be followed.

3.03 STARTING EQUIPMENT DATA LIST

- A. Obtain data from the equipment supplier shop drawing submittals or equipment nameplates, and prepare a complete tabulation of all motors over 1/3 hp, electric heaters over 3 kW, and starting equipment for both, to be furnished on the project.
 - 1. Include in tabulation firm the following information:
 - a. Name and identification of equipment.
 - b. Manufacturer.

- c. Horsepower or kilowatt rating.
 - d. Voltage.
 - e. Phase.
 - f. Speed.
 - g. Full load current.
 - h. Locked rotor current or code letter.
 - i. Type of enclosure (open drip-proof, totally enclosed, fan cooled, etc.).
 - j. NEMA size of starter or contactor.
 - k. Overload heater size.
 - l. Type of starter (full-voltage, reduced-voltage, autotransformer, etc.).
 - m. Breaker trip setting or fuse size.
 - n. Voltage of starter operating coil.
 - o. If starter is at a motor control center, list motor control center number.
- 2. Final acceptance of the electrical system is contingent upon submittal of the complete motor and electric heater tabulation.
 - 3. Arrange tabulation in groups by MCC or building location.
 - 4. Furnish six copies of the tabulation to the Engineer when a submission is made.

3.04 DRAWINGS AND SPECIFICATIONS

- A. Drawings and specifications are typical of work to be done and of the arrangement desired. Provide accessories and appurtenances which the Engineer deems functionally necessary for a complete installation, whether or not explicitly indicated or described.

3.05 RECORD DRAWINGS

- A. The Contractor shall maintain a master set of record drawings showing the changes and deviations from the contract drawings.
- B. A minimum of 30 days prior to application for Final Payment, submit two sets of drawings for approval that are marked to show the as-installed equipment, devices, raceway locations and wiring. The markings on the drawings are to be neat, clean and legible.

3.06 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 20

ELECTRIC WIRES AND CABLES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide wires and cables for complete electrical systems as indicated and in compliance with Contract Documents.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B3: Soft or Annealed Copper Wire.
 - 2. B8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. B33: Tinned Soft or Annealed Copper Wire for Electrical Purposes.
- B. Insulated Cables Engineers Association, Inc. (ICEA)/National Electrical Manufacturer's Association (NEMA):
 - 1. S-61-4021/WC 5: Thermoplastic Insulated Wire & Cable.
 - 2. S-66-524/NEMA WC 7: Cross-Linked-Thermosetting-Polyethylene Insulated Wire and Cable.
 - 3. S-68-516/WC 8: Ethylene-Propylene-Rubber-Insulated Wire & Cable.
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
- D. American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Electronic Industries Association (EIA):
 - 1. ANSI/TIA/EIA-568-B; Commercial Building Telecommunications Cabling Standards.
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 44: Thermoset-Insulated Wires and Cables.
 - 2. 83: Thermoplastic-Insulated Wires and Cables.
 - 3. 854: Service Entrance Cables.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Submit shop drawings and manufacturer's product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".

1.04 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.
- B. Deliver wire and cables in full reels protected against injury. Deliver reels with factory attached UL approved tags showing the manufacturers name and the type of insulation, size, and length of wire in each coil or reel.
- C. Accept wire and cable on site in manufacturer's packaging. Inspect for damage.
- D. Store and protect in accordance with manufacturer's instructions.
- E. Protect from weather. Provide adequate ventilation to prevent condensation.

1.05 DESIGN CRITERIA

- A. Wire for lighting, single phase circuits shall be Type XHHW or THWN-THHN.
- B. Wire for three phase circuits shall be Type XHHW.
- C. Service conductors shall be 600V rated type RHW.
- D. Single conductor wire for control, indication and metering shall be Type THWN-THHN No. 12 or 14 AWG, stranded.
- E. Multiconductor control cable shall be used for the underground system and shall be No. 12 or 14 AWG, stranded with overall jacket.
- F. Wire for process instrumentation shall be twisted shielded pairs No. 16 AWG, stranded with overall jacket.
- G. Ground wires shall be Type THW, green. Bare ground wires shall be soft drawn copper, 98 percent conductivity.
- H. Wire for power circuits installed in duct banks shall be type RHW.
- I. Multiconductor cables used in cable tray shall be TC-ER and VW-1 rated.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. 600V Cable:
 - 1. Okonite.
 - 2. Southwire.
 - 3. American Insulated Wire.
- B. Variable Frequency Drive Cables:
 - 1. Belden Wire and Cable.
 - 2. Southwire
 - 3. Okonite
- C. Multiconductor Tray Cables:
 - 1. Belden Wire and Cable.
 - 2. Southwire
 - 3. Okonite
- D. Control and Metering Wire:
 - 1. Belden Wire and Cable.
 - 2. Alpha Wire.
 - 3. Coleman Cable.
- E. Cable Fireproofing Tape:
 - 1. MAC Products, Inc.
 - 2. 3M Electrical Products.

2.02 MATERIALS AND COMPONENTS

- A. Furnish copper conductors. Material and stranding of conductors to conform to ASTM B3, ASTM B33, and to ASTM B8, for the appropriate class.
- B. Uncoated, soft or annealed copper wire conforming to ASTM B3.

- C. Wires and Cables for Maximum 600-Volt Power Circuits: For No. 8 AWG gauge and smaller provide type THWN/THHN or RHW. Where used in lighting or receptacle branch circuits provide No. 12 AWG gauge and No. 10 AWG gauge as solid conductor. Provide other wire with Class C stranding. Provide No. 6 AWG gauge and larger as XHHW-2 with Class B stranding. Provide wires and cable conforming to UL 83.
- D. Variable Frequency Drive (VFD) Cables – for use on load side of AFD units: 100% Ground Flexible VFD, 3 Conductor Tinned Copper XLPE Insulation M4 Color Code + Symmetrical Segmented Ground Bare Copper Stranded, Overall Dual Copper Tapes Helically Applied Shield, Black PVC Outer Jacket, 2000V TC-ER, 90C Dry/Wet, 2000V Flexible Motor Supply Cable, WTTC, 1000V CSA AWM I/II A/B, 2000V RW90 TC, Sunlight Resistant, UL Direct Burial, Oil Resistant. Refer to plans for conductor size.
- E. Multiconductor Tray Cables – Type TC-ER Control Cable 600 Volt Copper Conductors, Ethylene Propylene Rubber (EPR) Insulation XHHW-2 Chlorinated Polyethylene (CPE) Jacket, Control Cable Conductor Identification Method 1 Table 2. VW-1 Rated.
- F. Wires and Cables for Control, Indicating, Metering, or Alarm Circuits: Single and multiconductor control cable, copper conductors, Class B or C stranding. Insulation; 600-volt polyethylene, polyvinylchloride, or EPR. Continuous rating of 90C dry and 75C wet. Color coding conforming to Table K-2, ICEA/NEMA S-61-4021/WC 5.
- G. Shielded Cable for Instrumentation Wiring: 7-strand copper conductors, size No. 16 AWG. Insulate conductors individually with color coded polyethylene or polyvinylchloride. Twist pairs with varying lay (if more than one pair) and cover with cable tape and 100 percent coverage aluminum foil or tape shield and tinned copper drain wire. Jacket: flame-retardant polyvinylchloride. Where multi-conductor TSP cables are called for, each pair shall be individually shielded, continuous number coded, and the cable assembly shall have an overall shield and overall flame retardant PVC jacket. Cables: rated 600 volts, 90 degrees C, suitable for pulling in conduit and laying in cable tray, interlocked aluminum armor and outer PVC jacket.
- H. RTD and Multi Conductor Shielded Cable: Three or more copper conductors, stranded, minimum #18 AWG, PVC insulated for 600V, 100 percent coverage aluminum foil or tape shield, separate bare stranded copper drain wire, interlocked aluminum armor and outer PVC jacket, overall flame-retardant PVC jacket with NEC and UL approval. Suitable for pulling in conduit and laying in cable tray.
- I. Category 6A Cable: Category 6A cable shall consist of 4 twisted pairs, solid stranded, #24 AWG, of different lay and ground wires, enclosed by an overall conductive mylar backed aluminum foil shield. This shall be enclosed by an overall thermoplastic jacket. The cable shall meet the applicable requirements of ANSI/TIA 568 C.2. Provide cable with interlocked aluminum armor, rip cord, PVC inner and outer jackets, UL verified to Category 6A, insulated for 300V, and suitable for pulling in conduit and laying in cable tray.

PART 3 - EXECUTION

3.01 GENERAL

- A. Perform work in accordance with the National Electrical Code.
- B. Provide power cable identification as follows:

System Voltage	Neutral	Phase A	Phase B	Phase C
208/120V	White	Black	Red	Blue
240/120V	White- Gray Stripe	Black- Blue Stripe	Red- Blue Stripe	None
480/277V	Gray	Brown	Orange	Yellow

- C. Use green to identify insulated ground conductors.

NOTE: Colored insulation, tapes or sleeves may be used to provide color coding. Insulated ground conductors must have green covering.

- D. Permanently post means of identification of grounded and ungrounded conductors for each nominal voltage system at each panelboard and motor control center.
- E. In power and multiconductor cables manufactured without a grounding conductor identify one of the multiconductors as the equipment grounding conductor at each cable end and at every point where the conductors are accessible.

3.02 INSTALLATION OF WIRING

- A. Unless otherwise indicated, use no conductor smaller than No. 12 AWG for power, No. 14 AWG for control, and No. 16 AWG for shielded applications.
- B. Install conductors continuous from outlet to outlet and make no splices except within outlet or junction boxes.
- C. Install cable in underground raceway system without splices. There shall be no splices between connection points unless otherwise indicated.
- D. Draw all conductors contained within a single conduit at the same time.
- E. Apply wire pulling compound to conductors being drawn through conduits. Use pulling compound, Minerallac No. 100, Y-er-Eas, Yellow 77, High Performance Polywater Cable Lubricant or acceptable equivalent.
- F. Use no cable bend with radius of less than eight times its diameter.
- G. Wires and cables installed without prior submittal review are subject to removal at no additional expense.

- H. Use TSP cable for all low-level analog signals such as 4-20 mA, pulse type circuits 24 VDC and under, and other signals of a similar nature.
- I. Use RTD cable for connections between RTDs and transmitters or control system RTD inputs.

3.03 CONDUCTOR IDENTIFICATION

- A. Label each wire at both termination points. Carry individual conductor or circuit identification throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.
- B. Identify each wire in junction boxes, cabinets, and terminal boxes where total number of control, indicating, and metering wires is three or more and no terminal board is provided, including all power wire. Where no termination is made use a plastic-coated, self-adhesive, wire marker and where termination is made use a, plastic, pre-printed sleeve wire marker.
- C. In cases similar to above where terminal boards are provided for the control, indicating, and metering wires, identify all wires including motor leads and other power wires too large for connection to terminal boards, by sleeve wire markers as specified above.
- D. In manholes and handholes, identify each power wire by laminated plastic tag located so it is easily seen. Control wires to be bundled and marked as listed in conduit and wire schedule.

3.04 CONNECTORS, TERMINAL LUGS AND BOARDS

- A. For wiring of circuits consisting of No. 10 or No. 12 AWG solid wires, such as for lighting branch circuits, use self-insulated pressure type connectors for all splices or joints.
- B. Terminate all wires connected to terminal boards, terminal blocks, or to other similar terminals by means of ring and tongue, nylon self-insulated, tin-plated copper pressure terminals.
- C. Terminal boards shall be 600 volts and rated for 125 percent of the ampacity of the connected circuit. They shall have screw terminals, with white marking strips for wire identification, of the 4-, 6-, 8-, or 12-pole type, as necessary.
- D. Wire connections for which terminals are not supplied, for example, at solenoids or motor terminal junction boxes:
 - 1. 10 AWG and smaller: Use self-insulated pressure-type connectors.
 - 2. 8 AWG and larger: Use insulated, mechanical type with set screw or follower bearing directly on the wire. Split bolt connectors are not acceptable.

- E. Clearly and permanently mark terminal strips with ink or indelible pencil. Mark each wire consistently throughout entire system, using notation of wires given on manufacturer's wiring diagrams wherever possible.

3.05 FIELD TESTING

- A. Submit results of all cable tests on forms indicating cable size, voltage, and date with name of tester and witness.
- B. Test all field conductors for instrumentation and controls systems for opens, shorts, and grounds. Resistance values shall not be less than those recommended by the cable manufacturer.
- C. Provide a record of each instrumentation cable continuity verification and resistance value.

3.06 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide a single, complete, integrated grounding system, including conductors, raceways, and connections, as indicated and in compliance with Contract Documents, and in accordance with the National Electrical Code Article 250 and the National Electrical Safety Code, and the applicable Provincial Electrical Safety Codes and Regulations.
- B. Include grounding of switchgear, substations, motor control centers, electric equipment enclosures etc., outdoor substations, transformers, switch structures, etc.; ground grid systems with ground rod and water pipe connections; structural steel, and lightning protection system.
- C. Include grounding conductors completely inter-connecting water supply pipe, ground rods, ground grid, substation, switchgear and motor control center ground buses, other distribution equipment, and other groundable equipment.
- D. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
- E. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
- F. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
- G. Refer to specific Division 26 Sections for additional referenced codes and standards.

1.02 REFERENCES

- A. American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE):
 - 1. ANSI/IEEE C2: National Electrical Safety Code.
- B. ASTM International (ASTM):
 - 1. B3: Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

3. B33: Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

C. Institute of Electrical and Electronics Engineers (IEEE):

1. Standard 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Ground System.
2. Standard 142: Recommended Practice for Grounding of Industrial and Commercial Power systems.

D. National Fire Protection Association (NFPA):

1. 70: National Electrical Code.
2. 780: Lightning Protection Code.

E. Underwriters Laboratories (UL):

1. 467: Standard for Grounding and Bonding Equipment.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00 "Submittals":
- B. Submit shop drawings and manufacturers' product data in accordance with requirements of Section 26 05 10 "Electrical Work – General".
- C. Submit catalog and dimensional data for the following:
 1. Ground rods
 2. Exothermic welding
 3. Connecting hardware
- D. Submit grounding system test results.

PART 2 - PRODUCTS

2.01 MANUFACTURER'S COMPLIANCE

- A. Manufacturer's acceptance contingent upon products' compliance with the specifications.

2.02 MANUFACTURERS

- A. Ground Rods:

1. ERICO Products Inc.
2. Galvan Electrical Products.
3. Nehring Electrical Works.

B. Exothermic Welding:

1. ERICO Products, Inc.
2. American Brass Mfg. Co.
3. Orgo-Thermit, Inc.

C. Connecting Hardware:

1. American Brass Mfg. Co.
2. Thomas and Betts
3. Anderson Electric Corp.

2.03 MATERIALS AND COMPONENTS

A. Conductors:

1. Provide copper grounding conductors bare or insulated, sized as indicated. When not indicated on the drawing provide in accordance with the NEC. Provide protection of conductors in locations where physical damage would result from direct exposure.
2. Ground and bond wires for substations, main panels and distribution points, and ground rod connections shall be annealed bare copper conforming to ASTM B3, stranded, with 98 percent conductivity.
3. Equipment ground conductors run with circuit conductors and grounding electrode conductor shall be 600-volt with green insulation, unless noted otherwise on the Contract documents.
4. Unless noted otherwise, all conductors No. 8 AWG and larger shall be stranded, Class B in accordance with ASTM B8.
 - a. Uninsulated conductors shall be bare copper in accordance with ASTM B3, tinned in accordance with ASTM B33.
 - b. Use tinned-coated in corrosive environments including when buried in earth or embedded in concrete.

B. Ground Bus:

1. Provide a 4 by 1/4 inch (100 by 6 mm) copper bar complete with bolted type connectors as indicated.
2. Bus bar shall have 18 pre-drilled holes, two standoff insulators, two stainless steel mounting brackets and four stainless steel assembly bolts and lock washer.

C. Connectors and Fasteners:

1. Provide ground clamps which are UL listed for use on copper or brass pipes.
2. Provide ground clamps, for use on iron pipes, of galvanized or malleable iron, or of standard noncorrosive material for use on iron pipes.
3. Provide ground clamps, for use on pipes, with rigid metal base providing good contact by proper seating on the pipe. Do not use strap type clamps.

D. Ground Rods:

1. Ground rods shall conform to the requirements of NFPA 70 and UL Standard 467.
2. Ground rods shall be copper-clad steel rods not less than 3/4 inch (19 mm) in diameter and not less than 10 feet (3 m) long per section.
3. Ground rods shall be clean and smooth with the following characteristics:
 - a. Cone-shaped point on the first section.
 - b. Die-stamped near the top with the name or trademark of the manufacturer and the length of the rod in millimeters or feet.

PART 3 - EXECUTION

3.01 EXOTHERMIC WELDING

- A. Welding shall be by the exothermic process.
- B. Within the welding procedure, include the proper mold and powder charge and conform to the manufacturer's recommendations.
- C. Welding processes shall be the exothermic fusion type that will make a connection without corroding or loosening.
- D. The welding process shall join all strands and not cause the parts to be damaged or weakened.

- E. Completed connection or joint shall be equal or larger in size than the conductors joined and have the same current-carrying capacity as the largest conductor.
- F. Paint buried ground connection with a bitumastic paint.

3.02 INSTALLATION OF GROUNDING AND BONDING CONDUCTORS

- A. Install grounding conductors so that they will not be exposed to physical damage. Install connections firm and tight. Arrange conductors and connectors so no strain on connections.
- B. Run grounding conductors associated with direct burial cables in common trenches above cables except as indicated otherwise.
- C. Bury equipment grounding conductors 30 inches deep. Bring loops or taps up for connection to equipment or other items to be grounded.
- D. Where raceways are used to contain and protect grounding conductors, install in accordance with Section 26 05 33 "Raceway and Boxes for Electrical Systems" and Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems".
- E. Where bare grounding conductors are contained within metallic raceways, bond ends of raceways to conductors.
- F. Install loop type, low impedance, grounding system interconnecting all components so at least two grounding connections are provided for each major item of electrical equipment. Ensure that severing of any single grounding conductor in this system does not remove grounding protection on any major item.
- G. Connect structural steel to the external perimeter loop of grounding conductors installed around all sides of building foundation, buried at least 30 inches below grade. Connect to each vertical column by loop or tap. Connect two opposite points on external loop to two different points on grounding system.
- H. Buried and concealed ground connections shall use exothermic welding.
- I. Make accessible connections to structural members by exothermic welding process or by bolted connector. Connections to equipment or ground bus by bolted connectors.
- J. All metallic conduits, terminating at manholes and handholes, shall be grounded using UL approved grounding type bushings.

3.03 INSTALLATION OF GROUND RODS

- A. Install ground rods in manholes in accordance with requirements specified under the section Underground Distribution Systems. Connect each grounding conductor entering a manhole to ground rod by exothermic weld.

- B. Install ground rods where indicated. Install the top of the rod 12 inch (300 mm) below the ground surface.
- C. Make connection to overall grounding system as indicated. All connections to below grade grounding components shall be made using exothermic welds.
- D. Ensure that final resistance of interconnected ground system is 5 ohms, or less. Measure ground resistance in normally dry conditions, and not less than 48 hours after rainfall.

3.04 EQUIPMENT GROUNDING

- A. Ground each piece of electrical equipment by means of a grounding conductor installed in raceway feeding that piece of equipment. Grounding conductors installed in conduit with insulated conductors to be furnished with green, 600-volt insulation. Ground conductors are in addition to and not to be considered as the neutral wire of the system.
- B. Connect power transformer cases and neutrals to grounding system. Connect neutral ground connection at transformer terminal. Provide two separate, independent, diagonally opposite, connections for power transformers so removal of one connection will not impair continuity of other.
- C. Connect two separate ground connections from ground grid to ground bus of switchgear assemblies, motor control centers, switchboards and all outdoor substation and transformer equipment. Ensure that each connection for item of equipment is from different section of ground grid.
- D. Connect a grounding conductor between panelboard and grounding system. Where a grounding bar is furnished with panelboard, connect grounding conductor to bar.
- E. Conduits entering metal enclosures shall utilize bonding type locknuts and grounding bushings. Locknuts that gouge into the metal enclosures are not acceptable.
- F. Where conduits are not effectively grounded by firm contact with a grounded enclosure, apply grounding bushings on at least one end of conduit run. Conduit connections shall be wrench tight.
- G. Install a separate grounding conductor from ground system to motors of 100 horsepower and larger, in addition to raceway system. Ground motor ground connection to motor frame, independent of mounting bolts or sliding base. Ground motor to nearest point on grounding system, unless otherwise indicated.
- H. Connect grounding conductors from equipment in area where ground bus is required to ground bus. Connect ground bus to grounding system. Mount ground bus on 600 volt pedestal insulators.
- I. Connect lightning arresters to ground system by suitable conductors. Where lightning arresters are furnished with electrical equipment and grounding connections are not

inherently provided, ensure that suitable separate grounding conductor connects lightning arresters with system ground.

- J. Connect generator neutral to grounding system by a grounding conductor. Connect grounding conductor to generator disconnect enclosure and generator neutral on generator side of disconnect. Ground generator frame to ground grid.
- K. Ground each area lighting pole by ground rod driven near base of standard, in accordance with requirements of National Electric Safety Code. Connect ground rods to grounding conductor brought with street lighting feeder cable.
- L. Connect individual ground rods to the grounding loop using the direct burial grounding cable by exothermic weld. All connections to below grade grounding components shall be made using exothermic welds, unless the connections are made in hazardous areas which prohibit the use of exothermic weld connections.
- M. Bond individual cable tray sections with bonding jumpers.

3.05 SIGNAL GROUNDING

- A. Ground signal surge protection and shields of twisted, shielded cable using a signal bonding conductor. The signal bonding conductor shall be a continuous path from the instrument surge protection or shield to the grounding electrode conductor. The signal bonding conductor shall be isolated from the equipment grounding conductor for its entire path.
- B. Where convenient several signal bonding conductors may be combined, providing that all the following conditions are met:
 - 1. The combined signal bonding conductor shall have the equivalent cross section of the conductors that it was combined from or three times the cross section of the largest conductor that it was combined from, whichever is less.
 - 2. The combined signal bonding conductor shall be isolated from the equipment grounding conductor.
 - 3. Where two signal bonding conductors are combined use a three-port insulated splice.
 - 4. Where three or more signal bonding conductors are combined, use a copper bus mounted on 600-volt insulators. Attach each conductor to the bus using an insulated ring tongue lug and screw terminal.

3.06 FIELD TESTING

- A. Test grounding systems for ground resistance. Total resistance from any point on the ground network to the building counterpoise must not exceed 5 ohms.

- B. Ground resistance and counterpoise tests must be made during dry weather and no sooner than 48 hours after rainfall. Conditions of soil and weather shall be documented on test forms.
- C. Conduct tests using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Perform measurements in accordance with IEEE Standard 81.
- D. Indicating instrument must be self-contained and include a direct-current generator, synchronized current and potential reversers, crossed-current and potential coils, direct-reading ohmmeter, series resistors, and range-selector switch. Calibrate direct-reading ohmmeter for ranges of 0 to 20 ohms and 0 to 200 ohms.
- E. Place auxiliary grounding electrodes in accordance with instrument manufacturer's recommendations but not less than 50 feet (15 m) apart, in accordance with IEEE Standard 81.
- F. Perform continuity test on all power receptacles to ensure that the ground terminals are properly grounded to the facility ground system.
- G. Submit copies of test reports on ground system to the Owner.

3.07 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide supports from building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings as indicated and in compliance with Contract Documents.

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00 "Submittals".
- B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Stainless steel.

2.02 MANUFACTURED SUPPORTING DEVICES

- A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
- B. Fasteners: Types, materials, and construction features as follows:
 - 1. Expansion Anchors: Stainless steel wedge or sleeve type.
 - 2. Toggle Bolts: All stainless-steel springhead type.
 - 3. Powder-Driven Threaded Studs: Stainless steel, designed specifically for intended service.
 - 4. Nuts, Washers, and Bolts: Stainless steel.

- C. Conduit Sealing Bushings: Factory fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit passing through concrete floors and walls. Construct seals with stainless steel sleeve, stainless steel body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.
- D. U Channel Systems: Stainless steel channels, with 9/16-inch (14 mm) diameter holes, at minimum of 8 inch (200 mm) on center, in top surface. Provide fittings and accessories that mate and match with U channel and are of same manufacture.

2.03 U CHANNEL SYSTEMS

- A. Manufacturers, Stainless Steel Channel.
 - 1. Unistrut Corp.
 - 2. Power-Strut.
 - 3. B-Line Systems, Inc.
- B. Provide Type 316 stainless-steel channel with corresponding accessories.
- C. Channels, with 9/16-inch (14 mm) diameter holes, at minimum of 8 inch (200 mm) on center, in top surface.
- D. Provide fittings and accessories that mate and match with U channel and are of same manufacture.
- E. Provide channel of the proper material to match equipment classifications.

2.04 FABRICATED SUPPORTING DEVICES

- A. Shop or field fabricate supports or manufacture supports assembled from U-channel components.
- B. Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

2.05 FIRE RESISTANT JOINT SEALERS:

- A. Manufacturers:
 - 1. "Dow Corning Fire Stop Foam," Dow Corning Corp.
 - 2. "Pensil 851," General Electric Co.
- B. Two part, foamed-in-place, silicone sealant formulated for use in through penetration fire stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.

- C. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with ASTM E814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with structural system and with other electrical installation.
- C. Raceway Supports: Comply with NEC and following requirements:
 - 1. Conform to manufacturer's recommendations for selection and installation of supports.
 - 2. Strength of each support shall be adequate to carry present and future load multiplied by safety factor of at least 4. Where this determination results in safety allowance of less than 200 lbs (890 N), provide additional strength until there is minimum of 200 lbs (890 N) safety allowance in strength of each support.
 - 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 - 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 inch (25 mm) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch (6 mm) diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
 - 6. In vertical runs, arrange support so load produced by weight of raceway and enclosed conductors is carried entirely by conduit supports with no weight load on raceway terminals.
- D. Sleeves: Install in concrete slabs and walls and other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated wall or floor construction, apply UL listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.

- E. Conduit Seals: Install seals for conduit penetrations of slabs below grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- F. Conduit extending through roof shall pass through ceiling box at roof line.
 - 1. Provide 14 gage (1.9 mm) minimum copper box complete with watertight soldered seams and flanged to serve as pitch pocket for each conduit.
 - 2. Install conduit and pitch pocket in advance of roofing work.
- G. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with following:
 - 1. Fasten by means of wood screws or screw type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring tension clamps on steel. Threaded studs driven by powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
 - 2. Holes cut in concrete shall not cut main reinforcing bars. Fill holes that are not used.
 - 3. Load applied to any fastener shall not exceed 25 percent of proof test load. Use vibration and shock resistant fasteners for attachments to concrete slabs.

3.02 CHANNELS

- A. Support electrical components as required to produce same structural safety factors as specified for raceway supports.
- B. Install metal U channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- C. Equipment mounted on U-channel support stands shall use single or double channel with enough supports to withstand winds up to 90 mph. The use of angle supports extending from the front or rear of the support structure is a tripping hazard and is strictly prohibited.
- D. Install Type 316 stainless steel for mounting of electrical equipment in outdoor areas and on below grade, outside building and structure walls.
- E. Install stainless steel channels for interior building mounting of electrical equipment except for those locations listed above and unless otherwise indicated.

3.03 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide complete raceway systems, with matching accessories, fittings, boxes, and other hardware as indicated and in compliance with Contract Documents. When non-metallic raceway systems are specified, provide green insulated grounding conductor sized per National Electrical Code (NEC) requirements.
- B. All raceway runs are indicated diagrammatically to outline general routing of raceway. Unless specifically identified for installation in concrete walls or slabs, raceways shall be run exposed with raceway supporting systems. Avoid interfering with pipes, ducts, structural members, or other equipment. Any installation deviations from the contract requirements shall be corrected at no cost to Owner.
- C. Provide raceway systems in accordance with the following:
 - 1. Within finished walls or ceilings, use EMT raceway systems.
 - 2. In NEMA 12 or NEMA 1 areas, use galvanized rigid steel raceway systems.
 - 3. In NEMA 4 areas, and where subject to wetting or wash down, use PVC coated rigid steel raceway systems.
 - 4. In exterior building applications, use PVC coated rigid steel raceway systems.
 - 5. In chemical areas and those areas designated NEMA 4X, use PVC coated rigid steel raceway systems.
 - 6. Inside concrete slabs or walls, use PVC Schedule 40 raceway systems. Use PVC-coated rigid steel for all bends and where the conduit exits the concrete.
- D. All raceway systems shall be installed in accordance with the criteria described in this section. Any proposed deviations from these requirements shall be submitted to the Engineer in writing for review and disposition.
 - 1. Use Type 316 stainless steel support systems for exterior application and in NEMA 4 and NEMA 4X areas.
 - 2. All NEMA 1 and NEMA 12 areas shall use stainless steel support systems.
- E. Aluminum conduit and boxes are not acceptable products.

- F. All raceways shall be supported to NEC requirements. Raceways 2 inch (50 mm) outside diameter or greater shall be independently supported in a manner to meet the criteria.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):

- 1. RN-1: Polyvinylchloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- 2. TC-2: Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
- 3. TC-3: Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing

B. National Fire Protection Association (NFPA):

- 1. 70: National Electrical Code (NEC).

C. Occupational Safety & Health Act (OSHA).

- 1. Regulation 1910.7

D. Underwriter's Laboratories, Inc. (UL):

- 1. 1: Electrical Flexible Metal Conduit
- 2. 6: Rigid Metal Electrical Conduit
- 3. 94: UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
- 4. 360: Electrical Liquid-Tight Flexible Steel
- 5. 651: Schedule 40 and 80 PVC Conduit
- 6. 1684: UL Standard for Safety Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00 "Submittals".
- B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".

1.04 1.04 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.

- B. Items provided under this section shall be listed and labeled by UL or other Nationally Recognized Testing laboratory (NRTL).
 - 1. Term “NRTL” shall be as defined in OSHA Regulation 1910.7.
 - 2. Terms “listed” and “labeled” shall be as defined in NFPA 70, National Electrical Code, Article 100.
- C. Regulatory requirements:
 - 1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

1.05 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.
- C. Install supports for raceway systems greater than 2 inches (50 mm) in diameter to meet the seismic requirements indicated and specified.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Rigid Metal Conduit, intermediate metal conduit and polyvinylchloride-coated rigid steel conduit.
 - 1. Triangle/PWC, Inc.
 - 2. Perma-Cote Industries.
 - 3. Republic Steel Corporation.
 - 4. Robroy Industries.
 - 5. Allied Tube and Conduit.
- B. Polyvinylchloride (PVC) Conduit:
 - 1. Triangle/PWC, Inc.
 - 2. Robroy Industries.

3. Carlon Electrical Sciences, Inc.

C. Flexible Conduit:

1. American Flexible Conduit Company.
2. Anamet, Inc.
3. Electri-Flex Company.
4. International Metal Hose Company.

D. Boxes and Fittings:

1. O.Z./Gedney Company.
2. Crouse-Hinds Electrical Construction Materials.
3. Appleton Electric Company.

E. Support Systems:

1. Michigan Hanger Co., (O-Strut).
2. Thomas & Betts (Superstrut).
3. Unistrut Corp.

2.02 MATERIALS AND COMPONENTS

A. Rigid Metal Conduit:

1. Provide galvanized rigid metal conduit, each with a coupling on one end and thread protector on other end.
2. Hot-dip galvanize rigid steel conduit over entire length, along interior and exterior surfaces, including threads. Conduit shall conform to UL 6.

B. Flexible-Metal Conduit:

1. Provide flexible-metal conduit for use in dry areas and match fittings, size, and material to rigid conduit to which it is connected. Flexible-metal conduit shall conform to UL 1.
2. Provide liquid-tight flexible-metal conduit for use in damp areas consisting of flexible-metal conduit, with liquid-tight, sunlight-resistant jacket extruded over the conduit. Provide stainless steel, braided flexible conduit in NEMA 4X, corrosive areas. On larger than 1-1/4 inch (30 mm), furnish separate external ground wire. Liquid-Tight flexible-metal conduit shall conform to UL 360.

C. Polyvinylchloride (PVC) Conduit:

1. Provide PVC conduit, Schedule 40 and Schedule 80 conforming to NEMA Standard TC-2 and UL-651.
2. Fittings and Conduit Bodies: NEMA TC 3 as recommended by the conduit manufacturer.

D. Polyvinylchloride-Coated Rigid Steel Conduit:

1. Provide polyvinylchloride-coated (PVC-Coated), rigid steel conduit conforming to NEMA Standard RN 1 consisting of hot-dipped galvanized rigid steel conduit, as specified hereinbefore, with a polyvinylchloride jacket bonded to the outside of all conduit surfaces with a nominal thickness of 40 mils meeting the requirements of NEMA RN 1, 3.1. The adhesive strength of the bonding to equal or exceed tensile strength of the coating. Provide couplings and fittings for this conduit conforming to the requirements of NEMA RN 1, 3.5.
2. A two-part urethane coating shall be applied to the interior of all conduit and fittings at a two-mil thickness. The interior coating shall be flexible to allow field bending without cracking or flaking.

E. Boxes:

1. In NEMA 1 and NEMA 12 areas, provide standard, sheet-metal, outlet and junction boxes constructed of code-gauge, galvanized sheet steel. Size each box as required by the NEC.
2. In NEMA 4X areas, exterior and process areas, provide 316 stainless steel junction boxes with stainless steel screw clamp or 3-point latches, stainless steel hinges and welded mounting feet. Bolted on mounting feet are unacceptable. Device boxes shall have integral mounting feet.
3. Provide boxes containing fixture studs for hanging fixtures. Use concrete-tight boxes for installation in concrete. Do not use shallow boxes unless building construction is such that it is impossible to use standard-depth boxes.
4. Provide boxes and covers for polyvinylchloride-coated steel conduit made of galvanized cast iron, with a polyvinylchloride factory-applied coating over the galvanizing. Provide coating thickness of 40 mil (1.0 mm) minimum. Boxes shall have hubs with extruded sleeves extending beyond the hub in the same manner as specified for conduit couplings. Provide cover screws of stainless steel.
5. Provide cast boxes with covers or device plates suitable for the area classification. Use cover screws of stainless steel or high brass for iron boxes.

F. Fittings:

1. Provide cast-iron fittings of malleable iron or a mixture of gray iron and cast steel.
2. Provide suitable expansion fittings where conduits cross expansion joints. Equip these fittings with grounding straps, clamps, and copper bonding jumpers.
3. LB, LR, LL, and Tee conduit fittings shall be Form 4 with clamp covers secured with stainless clamps and screws. Covers secured with screws tapped into the fitting are not acceptable.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Perform all work in accordance with the NEC.
- B. Use no conduit less than 3/4-inch (20 mm) in diameter, unless otherwise indicated.
- C. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's printed instructions.

3.02 SEISMIC RESTRAINTS

- A. For conduits and other raceways installed in open areas, not adjacent to and secured to structural elements, and 2 inch (50 mm) outside diameter or greater, support such raceways using seismic restraints rated for the applicable project earthquake criteria.
- B. Methods of Restraining Raceways:
 1. Utilize stainless steel threaded rod with rod stiffeners and transverse channel braces at approximately 45 degrees angle, at 15 feet (4.5 m) on center, maximum, and on one side of rod support.
 2. Utilize longitudinal bracing with channel braces at 30 feet (9.1 m) on center, maximum.
 3. Strap raceways directly to transverse channel braces, using pipe strap with both ends of strap bolted into the channel brace.
 4. Do not rigidly brace raceways to different parts of a building that may respond differently during an earthquake. Seismic restraints shall not limit expansion and contraction of the raceway support system.
 5. Provide flexible connections for conduits 2 inch (50 mm) outside diameter or greater than when terminating to fixed equipment to prevent loss of raceway integrity in the event of an earthquake.

3.03 INSTALLATION OF FITTINGS

- A. Install expansion fittings wherever conduits cross structural expansion joints. Keep the fittings in line with conduit, and install with regard to temperature so that full working range of expansion is available.
- B. Do not install fittings to replace elbows and pull boxes, unless space or other problems make use of fittings necessary. Use oversize fittings whenever large cable is installed, in order to maintain proper bending radius.
- C. Terminate ends of all floor conduits installed for future use with couplings and readily removable plugs set flush with finished floor surface. Cap spare wall conduits at wall where they enter building.
- D. Equip ends of all conduits with conduit fittings. Fit conduits terminating at motor control center or power distribution equipment, or in box above or below, with grounding type bushings, or solidly ground by locknuts or other acceptable fittings. Connect each grounding bushing to ground bus by a bare or green-covered copper wire. Do not use ground wire smaller than 12 AWG. Install ground wire larger than 12 AWG when required by NEC. Where conduits terminate in unprotected areas or where bonding is required over expansion joint, flexible conduit or equivalent; use ground wires 6 AWG. copper or larger.
- E. Terminate conduits entering gasketed sheet-metal boxes or gasketed sheet-metal equipment enclosures with gasketed hubs.
- F. Terminate conduits entering nongasketed sheet-metal boxes or enclosures with double locknuts and insulated bushings, or with acceptable equivalent.
- G. Join raceways with fittings listed for the purpose. Make joints tight. Use raceway fittings compatible with raceway and suitable for use and location.
 - 1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 - 2. Use insulating bushings to protect conductors.
 - 3. Tighten set screws of threadless fittings with suitable tool.

3.04 INSTALLATION OF RACEWAYS

- A. Install exposed raceways parallel or at right angles to walls and ceiling beams. Make all changes in directions with listed bends, elbows, and pull boxes. Space parallel runs uniformly throughout. Secure in place by hangers and fasteners. Ground raceways by connection to properly grounded enclosures, bonding, or other means, to obtain permanent low resistance path to ground throughout installation. Ensure that raceway sections in single run and in parallel runs are of same type and finish.
 - 1. Run parallel or banked raceways together, on common supports where practical.

2. Install raceways level and square and at proper elevations. Provide minimum 7 feet (2 m) headroom.
- B. Support raceways concealed above suspended ceilings from slab above ceiling in same manner as exposed raceways. Do not support raceways from ceiling supports.
 - C. Provide cast-in-place inserts in concrete to support all runs, unless otherwise permitted. Use stainless steel sleeve type concrete anchors for installing boxes, and conduit supports. Provide Type 316 stainless steel nut, bolts, and washers, for use with concrete anchors.
 - D. Support conduits by hangers or pipe straps spaced according to NEC, but in no case more than 10 feet (3 m) on centers.
 - E. When specified on the Contract Drawings, install conduits in slabs as close to middle of concrete slabs as practicable without disturbing reinforcement. Do not use conduit with outside diameter exceeding one-third of slab thickness. Do not place conduits closer than three diameters on centers, except at cabinet locations where slab thickness is increased as permitted by Engineer.
 - F. Where conduits are concealed in bottom floor slab, place in concrete slab and not in fill below slab. Install in middle third of the slab thickness where practical, and leave at least 4 inches (100 mm) of concrete cover.
 1. Secure raceways to reinforcing rods and to prevent sagging or shifting during concrete placement.
 2. Space raceways laterally to prevent voids in the concrete.
 3. Run conduit larger than 1-inch (25 mm) trade size parallel to or at right angles to main reinforcement. When at right angles to reinforcement, place conduit close to slab support.
 - G. Stub-Up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs, and set flush with the finished floor. Flexible metal conduit may be used 6 inches (150 mm) above the floor. Where equipment connections are not made under this Contract, terminate ends of floor conduits installed for future use with couplings and readily removable plugs 8 inch (250 mm) above finished floor surface. Cap spare wall conduits at wall entrance to building.
 - H. Provide sleeves passing through exterior walls and slabs which are wall entrance seals of watertight construction. For new construction, furnish watertight seal between slab and sleeve, and between sleeve and conduit or cable similar to O.Z./Gedney Type "FSK". For existing construction, furnish watertight seal for use in core bit drilled holes that provides seal between concrete and conduit or cable similar to O.Z./Gedney Type "CSM1". Use wall-entrance seals of malleable iron with watertight sealing gland which may be tightened any time after installation.

- I. Do not use dissimilar metals in conjunction with each other. Use an insulation between adjoining surfaces so as to eliminate direct contact and any resultant electrolysis. Maintain electrical continuity of system. Use bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other acceptable materials as insulation.
- J. Install fittings to match raceway being used.
- K. Install expansion fittings wherever conduits cross structural expansion joints at connections between buildings. Keep fittings in line with conduit, and install with regard to temperature so that full working range of expansion is available.
- L. Where conduits pass through firewalls, grout hole around the conduit to the full depth of the material penetrated.
- M. Provide separate raceways, junction boxes, and wireways for all low voltage instrumentation raceways (50 volts and below) from control and power raceways.
- N. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely, and install the locknuts with dished part against the box; use two locknuts, one inside and one outside the box. Locknut/busing terminations are only acceptable in NEMA 1 enclosures.
- O. Threaded hubs shall be used to terminate conduits in all NEMA 12, NEMA 4X and enclosures used in hazardous areas. When terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- P. Install pull lines in all empty raceways. Use monofilament plastic line having not less than 200 lb (890 N) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.
- Q. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.
- R. Complete raceway installation before beginning conductor installation.
- S. Use temporary closures to prevent foreign matter from entering raceway.
- T. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends are not visible above the finished slab.
- U. Where metal conduits rise through floor slabs in wet areas, provide PVC Coated Rigid Steel conduits for a distance of 6 inches (150 mm) above and below slab grade.

3.05 BENDS

- A. Make all bends carefully to prevent distortion of circular cross section. Field bend conduit shall have an inside radius of not less than nine diameters.
- B. Where bends of less than nine diameters are necessary, use standard factory elbows. Size conduit to permit cable-bending radius within the factory elbow of at least eight times cable diameter.
- C. Allow no conduit greater than 50 feet (15.2 meters) to have more than two 90 degree bends or equivalent thereof between pulling points. For conduits less than 50 feet (15.2 meters) in length, allow only three 90 degree bends between pulling points.

3.06 CUTTING, THREADING AND CONNECTING

- A. Make all field cuts in conduits squarely, file cut ends, ream to remove rough edges and thread in accordance with NEC. No running thread permitted. Make all connections mechanically strong and tight, and with acceptable connectors. Where conduit surface coating is damaged or removed in the cutting, threading or reaming process, restore the surface to its original condition.

3.07 CONDUIT CLEANING

- A. Clean all conduit carefully before and after installation, ream ends free of burrs, and free inside surfaces from all imperfections likely to injure cable.
- B. After installation of each complete new conduit run, snake the run with band to which is attached a tube cleaner with cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit. Remove and replace all conduit through which mandrel will not pass.
- C. Use a sponge with steel brush to clean steel conduit and use a sponge with nylon brush to clean PVC conduits.
- D. After cleaning, protect ends of all conduit with standard caps to prevent entrance of water, concrete, debris, or other foreign substance.

3.08 CONDUIT DRAINAGE

- A. Where practicable, pitch conduit to drain to outlet boxes, or install so as to avoid trapping moisture. Where dips are unavoidable in exposed conduits, install fitting with drain hole at low point.

3.09 INSTALLATION OF BOXES

- A. Unless otherwise indicated, install sheet metal boxes only in dry, accessible locations. Install cast-metal boxes in exterior concrete or masonry walls, in floor slabs, in basements, all other below grade locations and elsewhere as indicated. Cast metal boxes shall be used

(unless otherwise indicated) where vapor-tight fixtures are required, for all surface mounting of wall switches and receptacles and for all outdoor use. Install pull boxes for motor control centers and large ceiling hung boxes where indicated.

- B. Install boxes in conformance with all the requirements of NEC. Install boxes designed for type of construction involved. Support boxes in same manner as required for conduit. Size boxes to provide bending radius for wire or cable of at least eight times diameter or in accordance with NEC, whichever is larger.
- C. Center all outlets in panels, or spaces and adjust to structural finish. Where specific locations are not indicated, locate outlets with respect to equipment served.
- D. Place all outlet boxes, junction boxes and pull boxes, in accessible locations when they are installed above or behind plastered ceilings, furred spaces, or suspended ceilings. Install access panels of suitable size. Mark all access panels for all boxes so panels can be readily located in future. Mark, using metal tabs or plastic buttons which cannot mark ceilings or walls, appropriate for type of construction being used.
- E. All penetrations shall be made from the side or bottom. Top entry is strictly prohibited.
- F. Provide NEMA 4X stainless steel boxes with covers and device plates suitable for the area classification. Provide stainless steel screws.

3.10 FLEXIBLE CONNECTIONS TO MOTORS AND EQUIPMENT

- A. At all motors and electrically operated equipment to which conduit connections are made, install with a complete connection between end of conduit and terminal box of motor or other equipment.
- B. Install the conduits in locations permitting direct connection to motors.
- C. Make connections between rigid raceway and motor or equipment subject to vibration and adjustment using flexible conduit. Make each connection with at least one quarter bend so that no vibration can be transmitted beyond flexible connection.
- D. Install flexible metal conduit, fittings, and accessories in dry areas in accordance with requirements of NEC.
- E. Install liquid-tight flexible metal conduit in damp, wet, process, and corrosive areas. Locate conduit to reduce the possibility of damage to the exterior coating. Use fittings that screw into flexible conduit and provide gaskets.
- F. Use maximum of 3 feet (1 m) of flexible conduit for recessed and semi-recessed lighting fixtures and; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid tight flexible conduit in wet, process, or damp locations. Install liquid-tight flexible metal conduit in areas subject to wetting due to fire protection sprinklers or broken or ruptured water line. Locate conduit to reduce the possibility of

damage to the exterior flexible conduit jacket. Use fittings that screw into flexible conduit and provide gaskets. Install separate ground conductor across flexible connections.

3.11 PROTECTION

- A. Provide protection and install in accordance with manufacturer printed instructions. The conduit and raceway equipment manufacturers, to ensure that coatings, finishes, and enclosures are without damage or deterioration at completion of project.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by the manufacturer.

3.12 FINAL SYSTEM ACCEPTANCE

- A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions and at no additional cost to the Owner.
- B. Label all raceways and boxes in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

3.13 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Section includes cable tray, cable tray accessories, hangers and supports as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. ASTM International (ASTM):

- 1. A123/A123M: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- 2. B633: Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
- 3. B766: Standard Specification for Electrodeposited Coatings of Cadmium

- B. National Electrical Manufacturers Association (NEMA):

- 1. VE 1: Metal Cable Tray Systems

- C. National Fire Protection Association (NFPA):

- 1. 70 - National Electrical Code (NEC)

- D. Underwriter's Laboratories, Inc., (UL):

- 1. 486A: UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors
- 2. 486B: UL Standard for Safety Wire Connectors for Use with Aluminum Conductors

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10.

C. Product Data for Each Component:

1. Show tray types, dimensions, and finishes.

D. Shop Drawings:

1. Detail fabrication and installation of cable tray, including plans, elevations, sections, details of components, and attachments to other construction elements.
2. Designate components and accessories, including clamps, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings.
3. Coordination drawings, including floor plans and sections drawn to accurate scale. Show accurately scaled cable tray layout and relationships between components and adjacent structural and mechanical elements.

E. Testing:

1. Factory certified test reports of specified products, conforming to NEMA VE 1.
2. Field test reports indicating and interpreting test results relative to compliance with performance requirements.

1.04 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements specified in Section 01 41 20.
- B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Comply with NFPA 70, "National Electrical Code" for components and installation.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 1. The Terms "Listed and Labeled": As defined in the "National Electrical Code", Article 100.
 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- D. Single-Source Responsibility: Cable tray components shall be product of single manufacturer.

1.06 SEQUENCING AND SCHEDULING:

- A. Coordination: Coordinate layout and installation of cable tray with other installations.
 - 1. Revise locations and elevations from those indicated as required to suit field conditions and as accepted by the engineer.

PART 2 - PRODUCTS

2.01 MATERIALS AND FINISHES:

- A. Conform to NEMA VE 1.
- B. Cable Trays, Fittings, and Accessories: Aluminum conforming to Aluminum Association alloy 6063-T6 for rails, rungs, and trays, 5052-H32 or 6061-T6 for fabricated parts.
- C. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304.
- D. Fabricate cable tray products with rounded edges and smooth surfaces.

2.02 SIZES AND CONFIGURATIONS:

- A. Conform to NEMA VE 1.
- B. Ladder-Type Trays: Class 20C unless indicated.
 - 1. Width: Refer to plans for width.
 - 2. Inside Depth: 6-inch.
 - 3. Cross-Rung Spacing: 9-inch.
 - 4. Minimum Fitting Radius: 24-inch.

2.03 CABLE TRAY ACCESSORIES:

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, manufactured with same materials and finishes as cable trays.
- B. Barrier Strips: Same materials and finishes as cable trays.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.04 WARNING SIGNS:

- A. Lettering: 1-1/2 inch (40 mm) high, black on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Materials and Fastening: Conform to Section 26 05 53.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine surfaces to receive cable tray for compliance with installation tolerances and other required conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

- A. Use cable tray of indicated types and sizes, complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold down devices, grommets, and blind ends.
- B. Install cable tray level and plumb according to manufacturer's written instructions, rough-in Drawings, original design, and referenced standards.
- C. Remove burrs and sharp edges of cable trays.
- D. Fasten cable tray supports securely to building structure as specified in Section 26 05 29 unless otherwise indicated.
 - 1. Locate and install supports according to recommendations of NEMA VE 1.
 - 2. Design supports, including fastenings to structure, to carry greater of calculated load multiplied by safety factor of 4, or calculated load plus 200 lbs (90 kg).
- E. Make connections to equipment with flanged fittings fastened to tray and to equipment. Support tray independently of fittings. Do not carry weight of tray on equipment enclosure.
- F. Install expansion connectors in cable tray runs that exceed 90 feet (27 m). Space connectors and set gaps according to NEMA VE 1.
- G. Make changes in direction and elevation using standard fittings.
- H. Make cable tray connections using standard fittings.
- I. Locate cable tray above piping except as required for tray accessibility and as otherwise indicated.

- J. Working Space: Install cable trays with sufficient space to permit access for installing cables.
 - K. Barriers: Install barriers to separate cables of different systems, such as power, communications, and data processing, or different insulation levels, such as 600 volts, 5,000 volts, and 15,000 volts.
- 3.03 GROUNDING:
- A. Connect cable trays to ground as instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A-486B.
 - B. Electrically ground cable trays and ensure continuous electrical conductivity of cable tray system. Use tray as an equipment ground conductor for itself only, not for connected equipment.
- 3.04 WARNING SIGNS:
- A. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.
- 3.05 FIELD QUALITY CONTROL:
- A. Grounding: Test cable trays to ensure electrical continuity of bonding and grounding connections.
 - B. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
- 3.06 CLEANING:
- A. Upon completion of installation of system, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.
- 3.07 PROTECTION:
- A. Provide final protection and maintain conditions in manner acceptable to manufacturer and Installer to ensure that cable tray is without damage or deterioration at Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by tray manufacturer.

2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by tray manufacturer.

3.08 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide complete underground distribution system as indicated and in compliance with Contract Documents.
- B. Conform to lines, grades, elevations, and dimensions. Resolve interferences with other underground conduit, piping or equipment, either new or existing with the Engineer. Match components suitable for proper installation.
- C. Provide concrete encasement of duct system where indicated. Include forms and reinforcing in installation. Perform work in accordance with Section 26 05 10 "Electrical Work – General".
- D. Provide Schedule 40 polyvinylchloride (PVC) conduit for power and control circuits and furnish and install PVC coated rigid steel conduits for instrumentation, and communication circuits.

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with requirements of Section 26 05 10 "Electrical Work – General".
- B. Provide "Record" drawings.

PART 2 - PRODUCTS

2.01 MANUFACTURER'S COMPLIANCE

- A. Manufacturer's acceptance contingent upon products' compliance with specifications.

2.02 MANUFACTURERS

- A. Polyvinylchloride (PVC) Conduit:
 - 1. Specified in Section 26 05 33 "Raceway and Boxes for Electrical Systems".

B. PVC Coated Rigid Steel Conduit, Galvanized:

1. Specified in Section 26 05 33 "Raceway and Boxes for Electrical Systems".

2.03 MATERIALS AND COMPONENTS

- A. Conduit Spacers: Furnish conduit spacers made of plastic to maintain spacing between conduits.
- B. Concrete: Minimum compressive strength, 3,000 psi (20 MPa).
- C. PVC coated rigid steel conduit shall be used underground for bends and when exiting the concrete.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONDUITS

- A. Lay conduits, indicated to be direct buried in the ground, in trench on 3-inch (75 mm) bed of sand and cover with an equivalent 3-inch (75 mm) bed of sand. Ensure that no rocks come in contact with conduit during backfilling. Dig trenches to depth and location indicated.
- B. Provide minimum separation of power and control conduits of 3 inch (75 mm) both vertically and horizontally. Build ductbank layer by layer, backfill and compact each layer to provide support for next layer.
- C. Separate power and control ducts from instrument ducts by a minimum of 12 inches (300 mm).
- D. Backfill ductbank in layers and tamp or "puddle" as directed by the Engineer. Provide yellow ductbank marker tapes, reading "Caution - Electrical Lines Below", over entire length of ductline. Locate tapes 12 inches (300 mm) below grade. Provide a tape for every 12 inches (300 mm) of width of ductline.
- E. Install conduit, indicated to be encased in concrete with spacers and reinforcing, as specified and as indicated. Concrete used to encase duct banks shall be dyed red in the truck before placement. Provide at least 3000-pound concrete.
- F. Install conduit runs following routing on drawing and running in straight lines. Where deviation from a straight line becomes necessary, install bends of radius which allow for rodding and installation of cable.
- G. Accomplish changes in direction of runs exceeding total of 10 degrees, either vertical or horizontal, by long sweep PVC coated rigid steel bends having minimum radius of curvature of 25 feet (8 m) Manufactured bends can be used at ends of short runs of 100 feet (30 m) or less, and then only at or close to the end of run. Provide long sweep bends made

up of one or more curved or straight sections and/or combinations thereof. Install manufactured bends with minimum radius of 36 inch (1,000 mm) where larger radius cannot be used.

- H. Lay ductlines to minimum slope of 4 inch (100 mm) per 100 feet (30 m) and slope to manholes and handholes, as indicated. Ductlines are to slope away from buildings.
- I. Install spacers at intervals of approximately 4 feet (1200 mm) and stagger between tiers of ducts to provide not less than 12 inches (300 mm) of longitudinal separation. Install base spacers to provide at least 3 inches (75 mm) between bottom of trench and underside of bottom conduits. Completely fill space with concrete. Firmly wire conduits and spacers together before concrete is placed.
- J. Ductbanks shall be formed, unless trench conditions allow for neat placement of concrete with specified clearances.
- K. Prior to placing of concrete, remove all dirt, sand, and any other debris from between conduits and from trench bottoms. Hold conduits in place to prevent floating or accidental movement.
- L. Stagger joints in conduits at least 6 inches (150 mm). Do not allow couplings to rest on bottom of trench. Install couplings for plastic conduit in accordance with manufacturer's recommendations.
- M. Install concrete encasements so minimum clearance of 12 inches (300 mm) from concrete to parallel pipes, lines, structures, etc., is maintained. Where ducts cross, minimum clearance of 6 inches (150 mm) is required. Do not allow the top of concrete to be less than 30 inches (750 mm) below finished grade or paving. Submit special conditions which may require lesser clearances or special conditions which may require greater than 30 inches (750 mm) depth to Engineer for acceptance.
- N. Where a connection is made to existing ductline, bond or dowel concrete encasement to existing encasement. Use waterstop between ductpours and between manholes or buildings and ductwork as indicated.
- O. Do not use power-driven vibrators for spading of concrete around ducts.
- P. Roll and grade backfill, and restore surface to condition equal to the site finish grade, or as otherwise indicated.
- Q. Locate ductbank markers at ends of all ductbanks except at manholes or handholes, at approximately every 200 feet (65 m) along duct run, and at each change in direction of duct run. Place markers approximately on ductbank. Install markers 6 inches (150 mm) square or round section by 3 feet (1 m) long made of Class B concrete. Imprint the letter "D" or cast it on top of the marker. Install top of duct markers flush in paved areas, protruding no more 2-inches above finished grade in unpaved areas. In finished lawns, allow marker to protrude 1/2-inch (12 mm).

- R. Keep conduits clean of concrete, dirt, and other substances during the course of construction. After the ductlines have been completed, pull a standard flexible mandrel not less than 12 inches (300 mm) long, having a diameter approximately 1/4-inch (6 mm) less than the inside diameter of the conduit, through each conduit, after which pull a brush with stiff bristles through each conduit to make certain that no particles of earth, sand, or gravel have been left in the line. Replace conduit runs that do not allow the passage of the mandrel at no additional cost to the Owner. Pneumatic rodding may be used to draw in the lead wire. Install in spare conduits a pull wire or rope, and plug and seal spare conduits after cleaning.

3.02 RECORD DRAWINGS OF UNDERGROUND WORK

- A. Furnish one set of marked copies of contract drawings, showing exact routing and depths of all underground conduit, duct handholes and manholes. Furnish scaled plot plans, showing principal outline of buildings and structures. Reference conduits, ducts, and manholes, and all bends deviating from straight line, dimensionally from fixed objects or structures.

3.03 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Identification of electrical materials, equipment, and installations as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. A13.1: Scheme for the Identification of Piping Systems

B. Institute of Electrical and Electronics Engineers (IEEE):

1. ANSI/IEEE C2: National Electrical Safety Code.

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00 "Submittals".

1. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".

B. Product Data:

C. Submit for each type of product specified.

D. Miscellaneous: Schedule of identification nomenclature to be used for identification signs and labels.

1.04 QUALITY ASSURANCE

A. Comply with the requirements specified in Section 01 43 00 "Quality Requirements".

PART 2 - PRODUCTS

2.01 RACEWAY AND CABLE LABELS

- A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ASME A13.1, NFPA 70, or as specified elsewhere.
- B. Components and installation shall comply with NFPA 70.
- C. Conform to ASME A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size.
 - 1. Color: Black legend on orange field.
 - 2. Legend: Indicates voltage.
- D. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl. Legend is over-laminated with clear, wear and chemical resistant coating.
- E. Pre-tensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color coded, acrylic bands sized to suit diameter of line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position.
- F. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inch wide (0.08 mm thick by 25 to 51 mm wide).
- G. Underground Line Warning Tape: Permanent, bright colored, continuous printed, vinyl tape with following features:
 - 1. Size: Not less than 6 inch wide by 4 mils thick (152 mm wide by 0.102 mm thick).
 - 2. Compounded for permanent direct burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed Legend: Indicates type of underground line.
- H. Tape Markers: Vinyl or vinyl cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- I. Aluminum, Wraparound Marker Bands: Bands cut from 0.014 inch (0.4 mm) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.
- J. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.

- K. Aluminum Faced Card Stock Tags: Wear resistant, 18 point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch (0.05 mm) thick, laminated with moisture resistant acrylic adhesive, and punched for fastener. Preprinted legends suit each application.
- L. Brass or Aluminum Tags: Metal tags with stamped legend, punched for fastener. Dimensions: 2 by 2 inch (51 by 51 mm) by 0.05 inch (1.3 mm).

2.02 ENGRAVED NAMEPLATES AND SIGNS

- A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ASME A13.1, NFPA 70, or as specified elsewhere.
- B. Engraving stock, melamine plastic laminate for Interior Use, 1/16-inch (1.6 mm) minimum thick for signs up to 20 square inches (129 sq cm), 1/8 inch (3.2 mm) thick for larger sizes.
 - 1. Engraved Legend: Black letters on white face.
 - 2. Punched for mechanical fasteners.
- C. Exterior, Metal Backed, Butyrate Signs: Wear resistant, non-fading, preprinted, cellulose acetate butyrate signs with 0.0396 inch (1 mm), galvanized steel backing, with colors, legend, and size appropriate to application. One quarter (1/4)-inch (6.4 mm) grommets in corners for mounting.
- D. Fasteners for Plastic Laminated and Metal Signs: Self tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts, flat washers and lock washers.

2.03 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1 piece, self-locking, Type 6/6 nylon cable ties with following features:
 - 1. Minimum Width: 3/16-inch (5 mm).
 - 2. Tensile Strength: 50 lb (222 N) minimum.
 - 3. Temperature Range: -40 to 185 degrees F (-40 to 85 degrees C).
 - 4. Color: As indicated where used for color coding.
- B. Paint: Alkyd-urethane enamel. Primer as recommended by enamel manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install identification devices according to manufacturer's written instructions.
- B. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
- C. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and or designations used for electrical identification with corresponding designations used in Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- D. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
- E. Self-Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.
- F. Identify feeders over 600 Volt with "DANGER-HIGH VOLTAGE" in black letters 2 inch (51 mm) high, stenciled with paint at 10 feet (3 m) intervals over continuous, painted orange background. Identify following:
 - 1. Entire floor area directly above conduits running beneath and within 12 inch (305 mm) of basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to conduits concealed within wall.
 - 3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.
 - 4. Surface of exposed conduits.
- G. Install painted identification as follows:
 - 1. Clean surfaces of dust, loose material, and oily films before painting.
 - 2. Prime Surfaces: For galvanized metal, use single component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy duty, acrylic resin block filler. For concrete surfaces, use clear, alkali resistant, alkyd binder type sealer.
 - 3. Apply 1 intermediate and 1 finish coat of silicone alkyd enamel.
 - 4. Apply primer and finish materials according to manufacturer's instructions.

- H. Install Caution Signs for Enclosures Over 600 Volt: Use pressure sensitive, self-adhesive label indicating system voltage in black, preprinted on orange field. Install on exterior of door or cover.
- I. Install Circuit Identification Labels on Boxes: Label externally as follows:
 - 1. Exposed Boxes: Pressure sensitive, self-adhesive plastic label on cover.
 - 2. Concealed Boxes: Plasticized card stock tags.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- J. Identify Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communications lines, install continuous underground plastic line marker located directly above line at 6 to 8 inch (150 to 200 mm) below finished grade. Where multiple lines installed in common trench or concrete envelope do not exceed an overall width of 16 inch (400 mm), use single line marker.
 - 1. Install line marker for underground wiring, both direct buried and in raceway.
- K. Color Code Conductors: Secondary service, feeder, and branch circuit conductors throughout secondary electrical system.
 - 1. Field applied; color coding methods may be used in lieu of factory coded wire for sizes larger than 10 AWG.
 - a. Colored, pressure sensitive plastic tape in half lapped turns for distance of 6 inch (150 mm) from terminal points and in boxes where splices or taps are made. Apply last 2 turns of tape with no tension to prevent possible unwinding. Use 1 inch (25 mm) wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.
 - b. Colored cable ties applied in groups of 3 ties of specified color to each wire at each terminal or splice point starting 3 inch (76 mm) from terminal and spaced 3 inch (76 mm) apart. Apply with special tool or pliers, tighten to snug fit, and cut off excess length.
 - 2. 208/120 Volt System – As follows:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.

3. 480/277 Volt System – As follows:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: White.
 - e. Ground: Green.
- L. Power Circuit Identification: Use metal tags or aluminum wraparound marker bands for cables, feeders, and power circuits in vaults, pull boxes, junction boxes, manholes, and switchboard rooms.
 1. Legend: 1/4-inch (6.4 mm) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
 2. Fasten tags with nylon cable ties; fasten bands using integral ears.
- M. Apply identification to conductors as follows:
 1. Conductors to Be Extended in Future: Indicate source and circuit numbers.
 2. Multiple Power or Lighting Circuits in Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color coding for voltage and phase indication of secondary circuit.
 3. Multiple Control and Communications Circuits in Same Enclosure: Identify each conductor by its system and circuit designation. Use consistent system of tags, color coding, or cable marking tape.
- N. Apply warning, caution, and instruction signs and stencils as follows:
 1. Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic laminated instruction signs with accepted legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
 2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch (9 mm) high lettering for emergency instructions on power transfer, load shedding, and or emergency operations.
- O. Install identification as follows:
 1. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes

communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide single line of text with 1/2-inch (13 mm) high lettering on 1-1/2 inch (38 mm) high label; where 2 lines of text are required, use lettering 2 inch (51 mm) high. Use black lettering on white field. Apply labels for each unit of following categories of equipment.

- a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Electrical switchgear and switchboards.
 - d. Motor control centers.
 - e. Motor starters.
 - f. Push button stations.
 - g. Power transfer equipment.
 - h. Contactors.
 - i. Remote controlled switches.
 - j. Control devices.
 - k. Transformers.
 - l. Adjustable Frequency Drives.
 - m. Battery racks.
 - n. Power generating units.
2. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

3.02 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 05 70

ELECTRICAL SYSTEM STUDIES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide electrical system studies as indicated and in compliance with Contract Documents.
 - 1. Provide a short circuit, protective device coordination and arc-flash study for the electrical distribution systems constructed under this contract. The study shall consider the electrical utility system upstream protective devices down to the 208Y/120V transformer secondary. The study shall include calculations used to verify the short circuit ratings of the electrical distribution equipment to be provided under this contract and to identify the required settings of associated protective devices.
 - a. Provide a report summarizing the coordination study including: one-line of system, relay and breaker setting tabulation, relay, circuit breaker, and fuse protective device coordination and short circuit calculation, all prepared by an independent specialty firm. Device calibration and settings are to be based on the results of this coordination study.
- B. The Contractor shall employ the services of a specialty firm, subject to review, with the specified demonstrated capability for calibrating and setting protective devices as specified herein.
- C. Changes and additions of equipment characteristics based on the actual equipment supplied may be suggested by the results of the short circuit and protective device coordination studies. Submit suggested changes and additions as a part of the study. Field settings of devices, adjustments, and minor modifications to equipment that are required to accomplish conformance with the accepted short circuit and protective device coordination studies shall be provided at no additional cost.
- D. The Contractor shall be responsible for providing and installing arc flash hazard equipment labels in accordance with electronic label templates provided with the electrical system study. Labels shall be provided for all electrical distribution equipment rated 120 VAC and above including but not limited to switchgear, switchboards, transformers, panelboards, disconnect switches, and vendor-supplied control panels containing power distribution equipment.
- E. Provide the following scenarios as a minimum:
 - 1. Water Treatment Plant on Utility.

2. Pump Station/Clearwell on Utility.
3. Water Treatment Plant only on Generators.
4. Pump Station/Clearwell only on Generators.
5. Water Treatment Plant and Pump Station/Clearwell combined on Generators.

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE):
 1. C37.010: Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 2. 242: IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 3. 519: IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power System.
 4. 1584: IEEE Guide for Performing Arc-Flash Hazard Calculations
- B. National Fire Protection Association (NFPA):
 1. 70E: Standard for Electrical Safety Requirements for Employee Workplaces.
- C. National Electrical Manufacturer's Association (NEMA):
 1. Z535: Safety Alerting Standards

1.03 SUBMITTALS

- A. Submittals of electrical distribution equipment affected by the study are not to be submitted until successful review and approval of Short Circuit Study.
- B. The approved remaining reports shall be completed, and a copy sent to the electrical distribution equipment manufacturer 45 days before the equipment is shipped to the Work site. The report shall be provided to the Engineer no later than 90 days before the equipment is shipped to the Work Site. Shipment and delivery of equipment will not be accepted at the Work site until the study has been completed, submitted, and approved by the Engineer.
- C. Submit the following in accordance with Section 01 33 00.
 1. Short circuit and protective device coordination study for review and acceptance, concurrent with the preliminary shop drawing submission for the main electrical distribution system equipment and overcurrent protective devices. Submit an initial

study for comment and a final study, with all electronic files, at the completion of the project.

- a. The study shall be performed using the latest edition of one of the following commercial software programs.
 - (1) EasyPower
 - (2) SKM System Analysis
 - b. The study shall consider the effects of motor contribution during fault conditions, at various buses in the system.
 - c. The study shall include cable sizes, cable lengths and raceway types for considering the effects of cables impedance in the system based on information to be provided by the Contractor.
 - d. The maximum fault contribution at the incoming source(s) shall be documented via correspondence from the authority responsible for this source(s).
 - e. Transformer inrush points and damage curves shall be plotted on coordination curves.
 - f. Obtain from the engine generator supplier, reactance values, protective device type and data and generator decrement curves.
 - g. Plot on common drawings, single line diagrams and the curves for each protective device to verify proper selectivity and protection for all components of the system for both the normal utility and standby generator source. Label each device uniquely.
 - h. Identify recommended settings for all devices.
 - i. Devices which do not provide full selectivity and coordination are not to be used as a recommended device in the study.
2. Voltage drop motor starting study to determine system voltage dip or power in rush limitations at all locations of the distribution system due to the starting of the largest equipment.
 3. This study shall consider starting when the system is powered from the utility and from the standby generator sources.
 4. Voltage and current total harmonic analysis study at all points of common coupling and main distribution buses for cases when system powered from utility and standby generator sources.

5. After review of coordination study, the Contractor shall set all devices based on the study.
6. Qualifications of specialty testing and/or study firm, as specified.
7. Arc Flash Hazard Labels
 - a. Submit all arc flash hazard equipment labels prior to printing and application to electrical equipment.
 - b. Label Construction
 - (1) Material: Vinyl, in accordance with NEMA/ANSI Z535.
 - (2) Size: 4-inches x 6-inches.
 - (3) Outdoor Life: 5 years.
 - (4) Min/Max Service Temperature: -40°F to 200°F.
 - (5) The labels shall be printed using a thermal transfer printer.
 - (6) Labels shall be resistant to chemicals, moisture, and UV light.

1.04 QUALIFICATIONS OF SPECIALTY FIRM:

A. Submit evidence of the following:

1. Firm's experience:

- a. Specialty firm shall have been in the business of the type of work specified, for at least the past five years.
- b. The firm shall have a minimum of five projects of equal or greater size, service, and the type of equipment specified.
- c. At least the following information must be submitted:
 - (1) The number of years the firm has been in the business of performing coordination studies.
 - (2) Summary of five previously performed studies including:
 - (a) A brief description of each study.
 - (b) Name of owner of installation on which study was performed with address, telephone number, and contact person.
 - (c) Date of study.

- (3) List of projects and contact persons for which protective device settings were performed.
 - (4) Any other information indicating the firm's experience, ability to perform the work, and business status.
- B. Firm shall have a licensed Professional Electrical Engineer supervise all work and seal all reports.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 SHORT CIRCUIT STUDY

- A. Perform a short circuit study in accordance with ANSI Standard C37.010 to verify the adequacy and correct application of circuit protective devices and other electrical system components.
- B. The study shall address the case when the system is being powered from the utility source as well as from the on-site generating facilities. Minimum and maximum possible fault conditions shall be covered in the study.
- C. Include the fault contribution of all motors. Horsepower shown in the Contract Documents may be used to calculate fault contribution of motors. In the short circuit study VFDs shall be replaced by conductors of the same size as the branch circuit conductors.
- D. Calculate short-circuit momentary duties and interrupting duties on the basis of an assumed bolted 3-phase short circuit at each bus. The short circuit tabulations shall include X/R ratios, asymmetry factors, kVA and symmetrical fault-current. Where ground fault protection is specified, provide a ground fault current study for the same system areas, including the associated zero sequence impedance diagram. Include in tabulation form, fault impedance, X/R ratios, asymmetry factors, motor contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.
- E. The studies shall include representation of the site power system, the base quantities selected, impedance source data, calculation methods and tabulations, one-line diagrams, conclusions and recommendations.

3.02 PROTECTIVE DEVICE COORDINATION STUDY:

- A. Provide a protective device time current coordination study with coordination plots of current limiting devices, plus tabulated data, including ratings and settings selected. In the study, balance shall be achieved between the competing objectives of protection and

continuity of service (with emphasis on continuity of service) for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.

- B. Provide separate plots for utility and generator operation as applicable. Show maximum and minimum fault values in each case. Multiple power sources shown in one plot is not acceptable.
- C. Each primary protective device required for a delta-to-wye-connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line-to-ground faults. Separate low voltage circuit breakers from each other and the associated primary protective device, by a 16 percent current margin for coordination and protection in the event of line-to-line faults. Separate protective relays by a 0.4 second time margin when the maximum 3 phase fault flows to assure proper selectivity. The protective device characteristics or operating bands shall be terminated to reflect the actual symmetrical and asymmetrical fault-currents sensed by the device. Provide the coordination plots for 3 phase and phase-to-ground faults on a system basis. Include all devices down to largest branch circuit feeder circuit breaker. Include all adjustable setting ground fault protective devices.
- D. Identify discrepancies in the conclusions and recommendations of the report. Upon resolution of discrepancies and recommendation, update all associated analyses and revise the affected studies.
- E. The coordination plots shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated upstream power system relays, fuse or system characteristics, significant motor starting characteristics, significant generator characteristics, complete parameters for power, and substation transformers, complete operating bands for low voltage circuit breaker trip devices, fuses, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall indicate the relay instantaneous elements, the magnetizing inrush, and ANSI transformer damage curves, the low voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault-currents.
- F. The thermal limit of all feeder cables to each bus and large motors, where applicable in the study, shall be shown.
- G. No more than six devices shall be shown on one coordination plot. Of these six curves, two (the largest upstream device and the smallest downstream device) shall repeat curves shown on other coordination plots in order to provide cross reference. Give each unique protective device curve in the study a study-unique number or letter identifier to permit cross reference between plots. Do not use identifier letters or numbers more than once.

- H. Each primary protective device required for delta-wye connected transformer shall be selected so that the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to assure protection for secondary line-to-ground faults.
- I. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings. Include C.T. ratio, burden and all other calculations required for the determination of settings.

3.03 MOTOR STARTING/RUNNING STUDY:

- A. Provide a motor starting study for all large electric motors and drives over 100 Hp in size to determine voltage dip or power inrush limitations at selected locations due to starting of motors. Define minimum system voltages and compare to standard equipment voltage capabilities.
- B. Provide a complete independent set of current-time characteristic curves for all motors 100 Hp (75 kW) and above indicating coordination between the protective relays and the thermal characteristics of the motor.
- C. Obtain from the motor supplier the necessary information to perform the study. Certified curves for "Safe Time vs. Current at 100 percent Voltage" and "Accelerating Time vs. Current at 100 percent Voltage" are absolutely necessary and shall become part of the final report.
- D. Provide recommended settings for all motor protective devices supplied under this contract.

3.04 ARC FLASH HAZARD ANALYSIS:

- A. Perform arc flash hazard analysis for the following items:
 - 1. Panelboards
 - 2. Control panels with voltage over 50 Volts
 - 3. Motor control centers
 - 4. Transformers that have auxiliary electrical devices operating at over 50 Volts
 - 5. Automatic transfer switches
- B. Methods of performing analysis:
 - 1. Use NFPA 70E article 130 tables if the short circuit study shows that the condition for those tables are met.
 - 2. Otherwise use IEEE 1584 calculations

- a. If the conditions fall within the IEEE 1584 parameters use the IEEE 1584 calculations based on actual OCPD curves and settings.
 - b. If the conditions do not fall within the 1584 parameters, use the Lee method.
- C. Label each item for which the calculations were performed with the following information:
 - 1. Limited approach boundary
 - 2. Information required by NFPA 70E, 130.2(D)(2).
 - 3. Restricted approach boundary
 - 4. Personal protective equipment required within restricted approach boundary
 - 5. Flash protection boundary
 - 6. Personal protective equipment required within flash protection boundary
 - 7. Prohibited approach boundary

3.05 FIELD TESTING

- A. Provide in accordance with Section 01 43 00 and as specified.
- B. Integrate results of this study with functional testing of the contract electrical equipment in accordance with Section 26 05 10 “Electrical Work – General”.

3.06 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 90

ELECTRICAL CONTROLS AND MISCELLANEOUS ELECTRICAL EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide and connect the electrical control equipment and miscellaneous electrical equipment, including such instruments and devices indicated and specified. Device enclosures for electrical equipment as indicated and in compliance with Contract Documents.
- B. Control panel enclosures and devices specified herein are provided under those specification sections which invoke this section for control panel requirements or as indicated on electrical drawings.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D178: Standard Specification for Rubber Insulating Matting
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250: Enclosures for Electrical Equipment (1000 volts maximum).
 - 2. ICS 1: Industrial Control and Systems General Requirements
 - 3. ICS 2: Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - 4. ICS 4: Terminal Blocks for Industrial Use.
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
- D. Underwriter's Laboratories, Inc. (UL):
 - 1. 467: Standard for Grounding and Bonding Equipment.
 - 2. 486A: UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - 3. 486B: UL Standard for Safety Wire Connectors for Use with Aluminum Conductors.

4. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
5. 823: Standard for Safety Electric Heaters for Use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Wiring diagrams to show control interface points provided with other equipment.
- C. Shop drawings to include:
 1. Outline drawings with elevations.
 2. Equipment arrangement drawings.
 3. Anchor bolt location drawings.
 4. Electrical schematics and wiring diagrams.
 5. Electrical fuse/circuit breaker characteristic.
 6. Equipment performance curves and data.
 7. Bill of installation/assembly materials.
 8. Equipment weights.
 9. Completed manufacturer's data sheets.
 10. Sustainable design submittals.

1.04 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00 "Quality Requirements".
- B. Sustainability Standards Certifications.

1.05 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10 "Deliver, Storage and Handling".

PART 2 - PRODUCTS

2.01 MANUFACTURERS FOR ELECTRICAL DISTRIBUTION EQUIPMENT

- A. Siemens.
- B. Eaton
- C. ABB
- D. Schneider/Square D.
- E. Appleton Electric Company.
- F. Crouse-Hinds Company.
- G. O-Z/Gedney.

2.02 SAFETY DISCONNECT SWITCHES

- A. Provide heavy duty type, safety switches, with external operating handles, 3 PST, rated 600 volt, 60 Hertz with ampere rating as indicated, and having provisions for padlocking.
- B. Provide fuses for safety switches as indicated.
- C. Heavy duty safety switches to be UL listed, File E 2875 and 154828, and meet or exceed NEMA Standard KS1.
- D. Provide auxiliary electrical interlocks for motor heaters or other motor control circuits, including variable frequency drives (VFD), starter control where indicated.
- E. Provide the following type rating, unless noted otherwise on the plans.

Indoor Use	NEMA Type 12 SST
Outdoor Use	NEMA Type 4X SST
Indoor or Outdoor Use, Corrosive Area	NEMA Type 4X SST

2.03 CONDUIT AND WIRING

- A. Provide conduit and wiring necessary to make connections between instrument panels, consoles, cabinets and external equipment and devices.

2.04 PUSHBUTTON AND SELECTOR SWITCH STATIONS

- A. Provide HAND-OFF-AUTO switches, push buttons, tumbler switches and other accessory devices as necessary for the control of motors and other electrical equipment or devices.
- B. Provide pushbutton and selector switch stations designed for heavy-duty service and with momentary or maintaining contacts as indicated or as necessary for starting and stopping of equipment with 10 amp contact ratings.

- C. Provide heavy duty switches and pushbuttons, Square D Company, Class 9001 or approved equal. Indicating lights to be led cluster type.
- D. At stations provide nameplates with white letters on black background.
- E. Provide safety lockout station with position indication located near motor to prevent application of current. Where pumps are located on lower levels than driving motors, furnish safety lockout station near each pump or other item of equipment.
- F. Provide galvanized cast iron enclosures for NEMA Type 4 watertight stations.
- G. Provide fiberglass reinforced polyester NEMA Type 4X enclosures for stations located in highly corrosive areas. Provide gaskets and Type 316 stainless steel screws, to prevent entry of chemicals.

2.05 MANUAL MOTOR STARTERS

- A. Provide manual motor starters where indicated and for 120 volt, 60 Hertz fractional horsepower motors.
- B. Provide each manual motor starter with overload heater or heaters of suitable capacity for motor running overcurrent protection for motor it controls. Provide manual starters as single or 2 pole, as necessary, and with toggle mechanisms indicating OFF and ON positions.
- C. Manual starters to be located within sight of motors, as defined by NFPA 70 National Electric Code (NEC).

2.06 MANUAL MOTOR SWITCHES

- A. Provide manual motor switches where indicated and for 480 volt, 3-phase, 60 Hertz fractional horsepower motors, such as motor operated valves.
- B. Provide each manual motor switch with overload heater or heaters of suitable capacity for motor running overcurrent protection for motor it controls. Provide manual motor switches as single, 2- or 3-pole, as necessary, and with toggle mechanisms indicating OFF and ON positions. Switches shall be NEMA 4 rated.
- C. Manual motor switches to be located within sight of motors, as defined by NFPA 70 National Electric Code (NEC).

2.07 WALL MOUNTED COMBINATION STARTERS

- A. Unless otherwise indicated, provide each combination starter with motor circuit protector and full voltage magnetic starter. Provide starters in an enclosure that meets the requirements of the enclosure schedule. Provide motor circuit protectors and starters as specified in Section 26 24 19 "Motor Control Centers".

- B. Provide control transformer for the control circuit of each motor controller, rated 120/240 volts, single phase, 3 wire, 60 Hertz, of adequate VA capacity for operation of supplied equipment with spare 100 VA.
- C. Provide control transformer with current limiting primary fuses and secondary fuse.
- D. Provide LED cluster type indicating lights of heavy duty, oiltight unit rated at 120 volts.
- E. Provide heavy duty, oiltight type pushbuttons to provide momentary contacts or maintained contacts for starting and stopping the motor.
- F. Refer to plans for control diagrams.

2.08 SOLID-STATE REDUCED VOLTAGE STARTER

- A. Unless otherwise indicated, provide each solid-state reduced voltage starter with circuit breaker. Provide starters in an enclosure that meets the requirements of the enclosure schedule. Provide starters as specified in Section 26 24 19 "Motor Control Centers".
- B. Provide control transformer for the control circuit of each motor controller, rated 120/240 volts, single phase, 3 wire, 60 Hertz, of adequate VA capacity for operation of supplied equipment with spare 100 VA.
- C. Provide control transformer with current limiting primary fuses and secondary fuse.
- D. Provide LED cluster type indicating lights of heavy duty, oiltight unit rated at 120 volts.
- E. Provide heavy duty, oiltight type pushbuttons to provide momentary contacts or maintained contacts for starting and stopping the motor.

2.09 WALL MOUNTED CIRCUIT BREAKERS

- A. Provide manually operated circuit breakers, ambient compensated, providing thermal magnetic inverse time limit overload and instantaneous short circuit protection. Provide overload protection on all poles; trip settings as indicated.
- B. Provide circuit breakers as specified under Section 26 24 19 "Motor Control Centers".
- C. Provide time-current characteristic curves for each size of circuit breaker furnished.
- D. Provide circuit breakers housed in NEMA type enclosure indicated, having external operating handles with provisions for padlocking.

2.10 CONTROL PANELS AND ELECTRICAL ENCLOSURES

- A. Provide control panels as specified in Section 26 27 17 "Control Panels".

2.11 RUBBER MATS

- A. Provide rubber mats conforming to ASTM D-178 Type I, Class I: Mats shall be at least 4 feet wide and have a length at least equal to the panelboard, switchboard motor control center, or switchgear before which they are to be placed. Furnish two spare mats, each 4 feet long as spares.
- B. Place mats in front of switchboards, panelboards, motor control centers and switchgear. Place mats behind electrical assemblies with rear access.

2.12 CONTACTORS AND RELAYS

- A. Provide mechanically held, heavy duty type contactors (relays) for lighting control, rated 30 amps, 600 volts, with number of poles as indicated.
- B. Provide contactor in the required NEMA enclosure suitable for wall mounting. Provide circuit breaker or fuse protection on each ungrounded pole. Provide contactor similar to Square D Company, Class 8903, Type LX or approved equal.
- C. Provide control power transformer with primary and secondary fuse protection. Control power to be 120 volts, single phase.
- D. Provide timing relays by Allen Bradley, Series 700 or equal.
- E. Provide industrial grade relays, NEMA rated, Square D Company, Class 8501 or equal.

2.13 NAMEPLATES

- A. Provide nameplates for equipment (including pushbutton and selector switch stations) listed in this section and other controls furnished under this contract, to designate the equipment controlled and their function.
- B. Nameplates shall be laminated black bakelite with 1/4-inch (6 mm) high, white, recessed letters. Securely attach to the equipment with Type 316 stainless steel screws, or rivets. Adhesives, glue or cements will not be permitted.
- C. Provide all junction boxes, pull boxes, disconnect switches and control panels with a nameplate to designate the system wiring contained within.
- D. Install nameplates in a location near or on the equipment or devices.

2.14 HATCH POSITION/INTRUSION SWITCH

- A. Heavy duty turret head lever arm type switch. Provide an offset type lever arm with sufficient length to contact hatch lid.
- B. Rated NEMA 6P
- C. Rated 120 VAC, 6 amps.

D. Application:

1. Roof Hatches
2. Tank Hatches

E. Manufacturer:

1. Schneider Electric/Square D
2. Approved Equal

PART 3 - EXECUTION

3.01 WIRING OF MISCELLANEOUS DEVICES

- A. Make electrical connections required for recording and indicating instruments, and miscellaneous devices. Provide electrical supplies to metering, instrumentation, control, and alarm systems.
- B. Connect HAND-OFF-AUTO switches, safety switches, tumbler switches, and other accessory devices as indicated or necessary for control of motors and other electrical equipment or devices.
- C. Install conduit and wiring and make electrical connections between all instrument panels, consoles, cabinets, and external equipment and devices. Panels, cabinets, etc., are indicated.

3.02 WIRING OF EQUIPMENT FURNISHED UNDER OTHER SECTIONS

- A. As specified in Section 26 05 10 "Electrical Work – General", install conduit, wiring, and connections for equipment and devices furnished under other Sections of specifications, and as indicated.
- B. Unless otherwise indicated, control equipment, relays, control wiring, conduit, and connections for control of heating, ventilating, and air conditioning systems are provided as specified in Section 23 09 00 "Instrumentation and Control for HVAC". Refer to mechanical specifications and drawings for locations of pressure-operated control switches, float switches, butterfly valves, solenoid operated valves, sump pumps, metering instruments, control panels, alarm actuating contacts, indicating lamps, limit switches, and other devices requiring wiring or interconnections with equipment supplied under Electrical Sections of these specifications.

3.03 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 08 13

FIELD INSPECTION AND ACCEPTANCE TESTS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Perform electrical system tests to demonstrate that each component of each system is in proper working order and in accordance with applicable codes, manufacturer's instructions, drawings and specifications as indicated and in compliance with Contract Documents. Tests are in addition to, and no substitution for, factory tests of individual equipment.
 - 1. Perform insulation and ground resistance tests before operating tests.
 - 2. Determine proper rotation of motors before permanent connections are made.
- B. Testing shall be performed to:
 - 1. Provide initial acceptance tests and recorded data that can be used as a benchmark for future routine maintenance and troubleshooting by facility operating staff.
 - 2. Ensure a successful start-up with a minimum of last-minute interruptions and problems.
 - 3. Determine the suitability of the equipment and systems for energization and placing into operating service.
 - 4. Provide assurance that each system component is not only installed satisfactorily but performs, and will continue to perform, its function in the system with reasonable reliability throughout the life of the facility.
- C. Provide all supervision and labor, materials, tools, test instruments or other equipment or services and expenses required to test, adjust, set, calibrate, functionally and operationally check all work and components of the various electrical systems and circuitry throughout the installation. Provide sufficient personnel to assist in any additional checks they may require for acceptance, start-up, run-in and placing the equipment and systems into continuous service.
- D. The tests and inspections performed shall in no way relieve the Contractor of the responsibility for the performance of the tests, check outs, and inspections specified under other sections of the specification during construction.
- E. The listings and descriptions of the tests, and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and

sometimes repetitive) checks and tests may be necessary throughout the job, prior to final acceptance by the Owner.

- F. Pay all costs for tests including expenses incident to retests occasioned by defects and failures of equipment to meet specifications.
 - 1. Replace wiring and equipment found defective, or failing to meet specified requirements, without charge, unless written acceptance for repair is given by Engineer.
 - 2. Unless otherwise specified, the Owner will supply electric power necessary for tests.

1.02 REFERENCES

- A. All inspections and tests shall be in accordance with the following applicable codes and standards latest revisions except as provided otherwise herein.
 - 1. All Standard, Special and Supplemental Conditions of the Contract.
 - 2. Association of Edison Illuminating Companies (AEIC).
 - 3. American National Standards Institute (ANSI):
 - a. Z244-1: American National Standard for Personnel Protection
 - 4. ASTM International (ASTM).
 - 5. Insulated Cable Engineers Association (ICEA).
 - 6. Institute of Electrical and Electronic Engineers (IEEE).
 - a. C2: National Electrical Safety Code
 - 7. National Electrical Manufacturer's Association (NEMA).
 - 8. International Electrical Testing Association (NETA):
 - a. ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
 - 9. National Fire Protection Association (NFPA):
 - a. 70: National Electrical Code
 - b. 70B: Electrical Equipment Maintenance
 - c. 70E: Electrical Safety Requirements for Employer Workplaces
 - d. 101: Life Safety Code

- e. 780: Lightning Protection Code
 - 10. Occupational Safety and Health Administration (OSHA):
 - a. Part 1926; Subpart V, 1926.950 through 1926.960
 - 11. State and Local Codes and Ordinances.
- B. All inspections and tests shall utilize the following references:
- 1. Project Design Specifications
 - 2. Project Design Drawings
 - 3. Project Electrical System Studies
 - 4. Manufacturer's instruction manuals applicable to each particular apparatus
- 1.03 SUBMITTALS
- A. Submit test plans and test data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
 - B. Submit test results.
- 1.04 SCHEDULING
- A. The Contractor shall be responsible for the preparation of proposed procedures and schedules for all inspections, tests, settings and calibrations specified or otherwise required prior to or during the check out for start-up and acceptance of all the electrical components, equipment and systems. This work shall be coordinated and to be compatible with both the work of other crafts and the project schedule. The above must be organized and submitted with all proposed testing and check out forms. The procedures shall provide specific instructions for the checking and testing of each component in addition to the system functional checks. Tests and inspections shall be scheduled as the job progresses and may require repetition in greater detail at a later stage of construction. All procedures submitted shall include job safety rules proposed.
 - B. Equipment shall be inspected and tested to determine its condition. See other applicable sections of the specifications and contract documents for required checks and responsibilities.
 - C. At any stage of construction and when observed, any electrical equipment or system determined to be damaged, faulty, or requiring repairs shall be reported to the Engineer. Corrective action may require prior approval.
 - D. Prior to check out and testing for start-up, ensure that all equipment and wiring is properly and permanently identified with nameplates and other identification as specified elsewhere. Check and tighten all terminals and connection points, remove all shipping

blocks and hardware, thoroughly clean all equipment, repair all damaged or scratched finishes, inspect for broken and missing parts and review and collect manufacturer's drawings and instructions for submittal to the Engineer. Make routine checks and tests as the job progresses and as necessary to ensure that all wiring and equipment is properly installed and wired.

- E. All testing and checkout work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress and for ensuring that important facts and questionable data are reported.
- F. All inspections, tests, and calibrations shall be reported in writing on forms submitted for review under Submittals. The recorded data form shall have the signatures of the persons conducting the tests and authorized witnesses. The forms shall be designed to serve as the test and inspection checklist for inspection requirements. "As-found" and "as-left" test data shall be recorded and reported in writing.
- G. The sequence of all tests and checks shall be such that the equipment can be energized immediately after the completion of the applicable tests.
- H. When applicable electrical tests and inspections specified herein, or otherwise required are completed and results reported and reviewed then the Contractor may consider that portion of the electrical equipment system or installation electrically complete. The Contractor shall then affix appropriate dated completion or calibration labels to the tested equipment. The Contractor shall notify the Engineer and Owner of electrical completion. If the Engineer or Owner finds completed work unacceptable, the Contractor will be notified in writing of the unfinished or deficient work which shall be corrected by the Contractor. The Contractor shall notify the Engineer in writing when all exceptions have been corrected. If later in-service operation or further testing determines problems attributable to the Contractor, these shall be corrected by the Contractor or suitable arrangements shall be made to suit operating circumstances.

PART 2 - PRODUCTS

2.01 TESTING EQUIPMENT

- A. Calibration:
 - 1. Furnish all material, test equipment, and power sources required for testing, calibrating and check out. All calibration and setting checks by the independent testing laboratory shall be performed with laboratory calibrated test instruments of appropriate accuracy. This test equipment shall have calibrations traceable to the National Bureau of Standards. Testing laboratory dated calibration labels shall be visible on all test equipment. Calibrations over 6 months old will not be acceptable on field test instruments. The accuracy of all test instruments shall be at least twice that of the accuracy of the equipment, device, relay or meter under test. All testing instruments shall be checked to insure satisfactory operation prior to proceeding

with the tests. Serial and model numbers of the instruments used shall be recorded on the test forms.

2. Make necessary openings in circuits for testing instruments and place and connect all instruments, equipment, and devices, necessary for the tests. Upon completion of tests, remove instruments and instrument connections and restore all circuits to permanent condition.

2.02 TESTING

A. Coordination:

1. Coordinate activities, and cooperate with others on project, to ensure that systems are energized when required, loads applied, and other requirements of Section are carried out on timely, coordinated basis.
2. Conduct tests in presence of Engineer. Notify Engineer seven calendar days or more in advance when any test to be performed, and do not start tests without Engineer's permission.
3. Other Sections of specifications require services of one or more manufacturer's representatives, to ensure that equipment supplied has been installed properly and adjusted to proper working order. Advise representative of all applicable tests in this Section, so that work will be coordinated, and tests combined where feasible.
4. It is important that equipment warranties or guarantees not be voided by testing and checkout work. The checks and tests to normally be supplemental to and compatible with the manufacturer's installation instruction leaflets and literature. Where deviations are apparent, the manufacturer's review shall be obtained prior to testing. Reasonable cooperation shall be extended to permit witnessing by the manufacturer's representative if so requested. Where any questionable repairs, modifications, significant adjustments, tests or checks are to be made, the Contractor shall contact the Engineer to determine if the work should be performed by or with the manufacturer's representative.

B. Preparation:

1. Make up no high and/or medium-voltage connections at service entrance, transformers, substations, motors, medium voltage motor control centers, switchgear and generator permanently until correct phase rotation of all equipment is determined. Install and insulate these connections temporarily, if necessary, while determining proper rotation. Make permanent connections after proper rotation has been established and subsequent to completion of insulation resistance and dielectric tests.

PART 3 - EXECUTION

3.01 INSULATION TESTS OF EQUIPMENT, CABLE, AND CIRCUITS

A. General

1. Perform DC insulation tests of the type specified on electrical equipment, apparatus and cables under any one or more of the conditions described as follows: At the time equipment such as motors, generators, transformers, power circuit breakers and switches, switchgear, motor control centers, bus duct, and similar electrical equipment is :
 - a. Delivered to the site for care, storage, and/or installation,
 - b. Prior to energization and/or placing into service and acceptance by the Owner,
 - c. When damage to the insulation is suspected or known to exist,
 - d. After repairs or modifications to the equipment affecting the insulation,
 - e. Routinely as necessary to determine or evaluate the condition of the insulation, especially moisture conditions, to determine the need for drying, cleaning or other maintenance work or protection,
 - f. Where lightning or other surge conditions are known to have existed on the circuit.
2. Insulation tests are required to be performed by the testing firm at various stages of construction. The equipment, cable and systems that require testing, the maximum test voltages, and the type tests required shall be in accordance with the applicable paragraphs of NETA.
3. List each circuit and measured resistance as test data.
4. Maintain record of all insulation resistance values. Identify conductor, or equipment, date that value was taken and resistance value. Arrange information in suitable neat tabular form and submit to Engineer.

3.02 SPECIFIC TESTS AND INSPECTIONS BY THE CONTRACTOR

A. General:

1. The following specific items of work shall be performed by the Contractor. The list is not all inclusive, nor does it define how the tests and checks are to be made. Refer to applicable sections of NETA and equipment specifications for additional details. The equipment and cable shall be deenergized and isolated as necessary to perform the tests.

2. The Contractor shall perform all tests and inspections as defined in the other sections of this specification. Tests and inspections required by these sections are not necessarily repeated under specific equipment in Paragraph 3.02
 3. All equipment received for the job and for which the Contractor is responsible to be stored and cared for per the manufacturer's instructions. It is the Contractor's responsibility to obtain such information even where the instructions are not shipped with the equipment.
- B. Equipment Test and Inspection During Construction and Prior to Acceptance Testing:
1. Motors (5 Hp and larger):
 - a. At the time of motor receipt, each motor shall be visually inspected for any physical damage and the motor meggered as described in Paragraph 1.e below.
 - b. All voltage motors shall be provided with adequate heating during storage. See Paragraph 3.01 for additional insulation tests for all motors of different voltages.
 - c. Before energizing any machine, visually inspect for serviceability. Check manufacturer's instruction manual for correct lubrication and ventilation. Verify that proper alignment has been performed. Check nameplate for electrical power requirements.
 - d. Test run all motors preferably uncoupled or unloaded, before placing into regular service. A check on the motor for rotation, speed, current and temperature rise to be made and results recorded. The proper color codes for phase identifications to be maintained. This may require lead swaps at the motor for proper rotation. A motor phase rotation meter shall be used prior to connection at motor to prevent later swaps.
 - e. Complete visual inspection and electrical test per NETA ATS. Section 7.15.1
 2. Grounding Systems:
 - a. All grounding loops and major equipment grounds shall be tested to remote earth or directly referenced to an extremely low resistance (approximately 1 ohm) reference ground benchmark. Visual inspection of all systems, raceway and equipment grounds shall be made to determine the adequacy and integrity of the grounding. All ground testing results shall be properly recorded, witnessed, and submitted.
 - b. Ground tests shall be performed in accordance with NETA ATS, Section 8.13 using a J. G. Biddle Company low resistance, Null balance type, ground testing with 'ohmmeter with test lead compensation in place. The test instrument shall be the type which compensates for potential and current rod resistances.

- c. Test each ground rod and submit tabulation of results to Engineer. Include identification of electrode, date of reading and ground resistance value in results.
 - d. Test each entire grounding system for continuity of connections and for resistance. Ensure that ground resistance of conduits, equipment cases, and supporting frames does not vary appreciably from that of system as whole and does not exceed 5 Ohms.
 - e. Where ground test results indicate the need for additional grounding conductors or rods that are not indicated on drawings or specified, additional grounding provisions shall be initiated to obtain the acceptable values. The Contractor shall be responsible for the proper installation of the grounding shown on drawings or specified and for the correction of improper installations as determined by inspections and tests.
- 3. Power Transformers:
 - a. At the time of equipment receipt, the exterior to be visually checked for any damage or any defects.
 - b. Perform complete inspection and electrical tests in accordance with NETA ATS, Section 7.2.
- 4. Low Voltage Switchgear: Refer to NETA ATS, Section 7.2. Perform all applicable tests and checks as described in NETA ATS, Section 7.2.
- 5. Protective Relays and Metering:
 - a. Prior to final check out as described in Paragraph 3.03, visually inspect and correct, where appropriate, all relays, meters, wiring and related circuitry for tightness of connections, physical damage, compliance with specifications and Vendor data, mechanical condition, freedom of movement, and presence of or possibility of moisture, dust, or other contaminants.
 - b. Clean, check, and pre-set all protective relays.
 - c. Complete inspection and electrical tests per NETA ATS. Section 7.9.
- 6. Low Voltage Motor Control Centers:
 - a. At the time of equipment receipt, the motor control centers shall be visually checked for any damage.
 - b. Perform inspection checks and electrical tests in accordance with NETA ATS. Section 7.16.2.

C. Distribution Transformers:

1. All 480-volt primary, air-cooled, transformers shall be given an insulation test, by means of a megger, after connections with the primary cables are complete. The supply cable shall be meggered with the primary winding and to the open-air circuit breaker. Secondary leads may be meggered with the secondary windings to the open load breakers.
2. Continuity and correctness of connections of all windings, and ratings shall be checked.
3. Perform inspection checks, and electrical tests in accordance with NETA ATS Section 7.2.3.

D. Wire and Cable:

1. Before energizing, the continuity and insulation resistance of every circuit external to equipment shall be measured with a megger from each wire to all others and ground and test results recorded on forms. Tests shall normally be conducted at voltages 500 volts or lower. High potential testing will normally be performed by the independent testing laboratory as described in Paragraph 3.03.
2. Insulation resistance measurements shall be taken of the following: (Refer to Paragraph 3.01 for additional information.)
 - a. Motor Feeders: With motors disconnected, measure and record insulation resistance from load side of contactors or circuit breakers. Repeat this test after motors are connected and just before energizing at lower voltage as limited by the maximum test voltage for the motor.
 - b. Motor Control Circuits (600 Volts): With push buttons and overcurrent devices connected, measure and record insulation resistance from phase to ground only. It will be necessary to lift the neutral ground on the control transformers to perform this test. Also, isolate any control elements that should not be meggered.
 - c. Lighting Panel Feeders: Measure and record insulation resistance with circuit breakers, lighting transformers and panelboards connected, but with lighting branch circuit breakers or switches open.
 - d. Lighting Branch Circuits: Measure and record insulation resistance after all lampholders, receptacles, fixtures, etc., are connected but before lamping.
 - e. Feeder Circuits: Measure and record insulation resistance with connections to circuit breakers made up but with breakers open and loads not connected.
3. All cables and wires shall be checked for proper identification numbering and/or color coding.

E. Overhead Conduit Systems:

1. The overhead conduit system shall be checked for proper installation by using the following check list: (This list not to be considered all-inclusive but as a guide for inspection).
 - a. Conduits are supported on appropriate independent supports (i.e., not on process piping, pipe ways, or piping hangers).
 - b. Exposed conduits are run in a neat workmanlike manner, parallel or perpendicular to structural members.
 - c. Conduits are routed as far away from possible fire hazards and heat sources as practical.
 - d. Conduits are supported at the required intervals.
 - e. Pull boxes and fittings are installed so that covers are easily removable. Verify that all covers are installed and tightly bolted with gaskets provided where needed.
 - f. Number of bends in the conduit does not exceed 270 degrees without a pull box installed.
 - g. Circular cross-sectional area is uniform at conduit bends. Single bends do not exceed 90 degrees.
 - h. Conduits are terminated in threaded hubs or bushings to prevent damage to wire.
 - i. Conduits joints have joint compound of the type specified and are tight and conduit ends are properly reamed and threaded not to engage less than 5 threads.
 - j. Pull fittings are of adequate size such that cable can be installed and replaced at a later date without the bending radius of the cable being less than code or manufacturer's requirements.
 - k. Seal fittings and/or sealing compound is installed at moisture barriers to prevent entry of moisture into equipment and/or where shown on plans.
 - l. Drains and conduit seals are installed on vertical conduit runs entering devices, equipment, and enclosures to prevent entrance of moisture.
 - m. Flexible conduit is installed at motors and other equipment as specified or required. Verify that all cabling and conduit runs are properly identified at each end.

F. Underground Conduit Systems:

1. Underground conduit systems shall be inspected and checked for compliance with standard practices, plans and specifications as the job progresses.
2. Upon construction completion of the underground conduit banks or runs and prior to backfill, the routing and the elevation and depth below grade shall be checked and any deviations from plans and/or specification to be recorded and in addition noted on record drawings.

G. Relay Panels, Operator and Instrument Control Panels, Communications Systems, Static Equipment, Programmable Controllers, Micro-Processors, Battery Systems and Other Miscellaneous Equipment:

1. Upon receipt of equipment, each item shall be inspected for damage, loose or missing parts.
2. Upon completion of equipment installation, all equipment and their control devices shall be visually and functionally tested for tightness of connections and for proper operation. In the case of battery systems, static inverters and the like, manufacturer's recommended test and installation manuals shall be reviewed and complied with. In the case of operator, instrument, and relay panels and cabinets or devices used solely for control, each circuit, where possible, shall be functionally tested for proper operation and conformance with drawings. Where functional testing is deemed undesirable by the Owner's Representative from a safety or plant operational standpoint, then continuity and terminal connection verification checks will be adequate. The Contractor shall insure that instruments and associated components cannot be energized until instructed by the Owner's Representative. For functional, operational, and calibration checks of instrument loops, refer to the instrument installation specifications.
3. Panelboard electrical checks shall be as included in the Wire and Cable section of this specification, Paragraph 3.02.E. Panelboards to be checked for proper circuit identification on the door schedule.

H. Sealing of Openings: The Contractor shall inspect the entire job with the Engineer to ensure that all openings are properly sealed as specified elsewhere.

I. Record Drawings: The Contractor shall maintain a master set or record drawings that shows changes and any other deviations from the base drawing. The markups shall be made as the changes are done. At the conclusions of the job, these master record drawings shall be complete and delivered to the Owner's Representative for forwarding to the design group.

3.03 LOSS OF AC POWER TEST

- A. After the satisfactory completion of all electrical system testing, perform a loss of AC power test. The main circuit breaker at the facility shall be placed in the "OPEN" position

by the Contractor using all required safety and personal protective equipment in accordance with NFPA 70E.

B. During this test the representatives from the following organizations shall be present:

1. Contractor
2. Division 40 SCADA System Supplier
3. Engine Generator System Supplier
4. Main Electrical Distribution Equipment Supplier
5. Adjustable Frequency Drive Equipment Supplier
6. Owner Representative

C. The test shall verify that all electrical equipment in the system can withstand the loss of utility AC power. Under standby generator power, all automatically started equipment shall be witnessed to start and accept load without tripping offline or initiating false alarms.

D. The test shall be performed with the facility operated at near or full load.

E. All alarms associated with the loss of utility power and startup of the standby generator system shall be recorded.

1. Any nuisance type alarms associated with microprocessor faults or troubles shall be investigated and action taken to prevent reoccurrence.
2. When all nuisance type alarms have been resolved, the test shall be repeated to verify acceptable operation of the facility electrical system upon loss of utility power.

3.04 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 20 00
ELECTRIC MOTORS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Low voltage electric motors and accessories, furnished under other Sections, and which are a part of equipment assemblies shall be in conformance with the requirements specified in this Section, unless otherwise noted. This section includes performance, and descriptive type specifications.
- B. Unless otherwise specified or approved, all electric motors furnished and installed by the Contractor shall conform to the requirements specified herein.
 - 1. Motors connected to Variable Frequency Drives shall be inverter duty rated in accordance with the requirements of NEMA MG-1.
 - 2. Motors rated 1 hp or greater shall be premium efficient type per NEMA MG-1.

1.02 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE).
 - 1. 112: Test Procedures for Polyphase Induction Motors and Generators.
- B. National Electric Manufacturer's Association (NEMA):
 - 1. MG-1: Motors and Generators.
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

- A. Shop drawings: Submit the following in accordance with Section 01 33 00 "Submittals".
- B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
 - 1. Descriptive literature and motor characteristics.
 - 2. Shop drawings and descriptive data to include:
 - a. Complete list of all motors to be furnished.

- b. Outlines, dimensions, weights, and wiring diagrams.
 - c. Location of main and accessories boxes with size of conduit entrance.
 - d. Efficiency and power factor at 1/2, 3/4 and full load.
 - e. Bearing design data and grease requirements.
 - f. Nameplate data.
 - g. Shop test report.
 - h. Field acceptance test report.
 - i. Strip heaters KW and voltage ratings.
 - j. Power factor correction capacitors, where required.
 - k. Built in overload protection device.
 - l. Starting restrictions, acceleration time-current curve of motor starting load (100 hp and larger).
 - m. Thermal damage curve and allowable stall time, full voltage (100 hp and larger).
3. Submit Pump, Motor and VFD Coordination Certificate. Refer to Section 01 33 00 "Submittals" for form.

1.04 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.
- B. Motors to comply with the latest reference standards listed below.
 - 1. National Electrical Code (NEC).
 - 2. Underwriters Laboratories, Inc. (UL).
 - 3. National Electric Manufacturer's Association (NEMA).
 - a. NEMA Standard MG-1 - Motors and Generators.
 - 4. Anti-Friction Bearing Manufacturer's Association, Inc. (AFBMA).
 - 5. American National Standard Institute (ANSI).
 - 6. Institute of Electrical and Electronics Engineers (IEEE).

- a. IEEE Standard 112 - Test Procedures for Polyphase Induction Motors and Generators.
 - C. Routine tests shall be performed on representative motors, and shall include the information described on NEMA MG1-12.54 Report of Test Form for Routine Tests on Induction Motors. Efficiency shall be determined in accordance with IEEE Publication No. 112, Method B. Power factor shall be measured on representative motors.
- 1.05 DELIVERY, STORAGE AND HANDLING
- A. Shipping:
 - 1. Ship motors assembled to driven equipment complete except where partial disassembly is required by transportation regulations or for protection of components.
 - 2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
 - 3. Deliver spare parts at same time as pertaining materials. Delivery to Owner after completion of work.
 - B. Receiving and Storage:
 - 1. Inspect and inventory items upon delivery to site.
 - 2. Store and safeguard equipment and material in heated storage facility as recommended by equipment manufacturer and required by Section 01 66 10.
 - 3. Protect motors from moisture at all times.
 - C. Prolonged Storage:
 - 1. For extended outdoor storage, remove motors from equipment and store separately.
 - 2. If storage is anticipated to be longer than two months, store in accordance with the manufacturer instructions including the following additional steps.
 - 3. Maintain motor space heaters energized.
 - 4. Fill the oil reservoirs of motors with sleeve bearings to the proper level with the specified oil.
 - 5. Motors with anti-friction bearings to receive an initial change of grease and then be re-greased every six months.
 - 6. Remove the motor shaft braces and the rotate motor shaft every two weeks. Replace the shaft braces prior to relocation to the installation site. Under no circumstances should the motor be lifted without the braces in place.

PART 2 - PRODUCTS

2.01 MOTOR MANUFACTURERS

- A. General Electric Company.
- B. Baldor-Reliance Electric/ABB.
- C. TECO-Westinghouse.
- D. Toshiba.
- E. WEG.

2.02 ELECTRIC MOTOR RATINGS

- A. Voltage Ratings:
 - 1. Unless otherwise specified, motors with ratings of 1/2 to 600 hp shall be rated 460 volt (nameplate rating), three-phase, 60 Hertz; motors of 1/3 hp or less to be rated 115-volt, single-phase, 60 Hertz.
- B. The following specific motor requirements shall be in the equipment specifications:
 - 1. RPM.
 - 2. Motor enclosure type.

2.03 MOTOR DESIGN REQUIREMENTS

- A. Motor heaters shall be supplied on all motors installed outdoors or in unheated areas. Heaters shall be of the cartridge or flexible wrap around type installed within the motor enclosure adjacent to core iron. Heaters shall be rated for 120 volt, single phase with wattage as required. The heater wattage and voltage shall be embossed on the motor nameplate.
- B. Unless otherwise specified or permitted all electric motors furnished and installed by the Contractor shall conform to the requirements hereinafter set forth.
- C. Motors connected to variable frequency drives shall be inverter duty rated.
- D. Every motor shall be of sufficient capacity to operate the driven equipment under all load and operating conditions without exceeding its rated nameplate current or power or its specified temperature limit at rated voltage. Each motor shall develop ample torque for its required service throughout its acceleration range at a voltage 10 percent below nameplate rating. Where indicated on the electrical drawings to be operated on a reduced voltage starter, the motor shall develop ample torque under the conditions imposed by the reduced voltage starting method.

- E. The motor shall have sufficient capacity to operate the driven equipment as given in the equipment detail specifications. The motor shall not be required to deliver more than its rated nameplate horsepower, at unity (1.0) service factor, under any condition of mechanical or hydraulic loading.
- F. The motor shall be suitable for rated horsepower and full service factor operation at minimum 5000 feet elevation above sea level.
- G. Type of Motors:
 - 1. All motors shall be NEMA Design B or of a type having starting characteristics and ruggedness as may be necessary under the actual conditions of operation and, unless otherwise specified, shall be suitable for full-voltage starting.
- H. Insulation:
 - 1. All motors shall have Class B or Class F insulation with temperature rise by resistance at full load rating of a Class B insulation in accordance with NEMA Standards for Motors and Generators, NEMA MG1, and based on a maximum ambient temperature of 40 degrees C unless otherwise specified.
 - 2. Insulation systems shall be manufacturer's premium grade, resistant to attack by moisture, acids, alkalies and mechanical or thermal shock for 480 volt motors. Provide 80 degrees C, Class B rise or better by resistance at 100 percent load and provide a Class F insulation system, suitable for an ambient temperature motor operation of 0 to 40 degrees C at no less than 4,500 feet above sea level for inverter duty motors. This temperature rise shall be met when motors are operated and controlled with the VFD(s). The motor insulation system shall have full capability to handle the common mode voltage conditions imposed by the VFD.
 - 3. Motors for outdoor service shall have vacuum/pressure impregnated epoxy insulation for moisture resistance.
 - 4. Insulation for inverter duty motor windings shall meet or exceed the Pulse Endurance Index for magnetic wire and shall not be injured when exposed to repeated pulse type waveforms, repetitive high voltage transients, switching frequency and rate of rise of the pulse. Class H varnish shall be used.
- I. Enclosures:
 - 1. Motors shall have a steel or cast iron frame and a cast iron or stamped steel conduit box, as specified below. Conduit box shall be split from top to bottom and shall be capable of being rotated to four positions. Synthetic rubber-like gaskets shall be provided between the frame and the conduit box and between the conduit box and its cover. Motor leads shall be sealed with a non-wicking, non-hygroscopic insulating material. A frame mounted pad with drilled and tapped hole, not less than 1/4-inch diameter, shall be provided inside the conduit box for motor frame grounding.

- a. Totally enclosed fan cooled: TEFC motors shall have a steel or cast iron frame, cast iron end brackets, cast iron conduit box, 1.15 service factor at 40 degrees C, tapped drain holes (corrosion resistant plugs for frames 286T and smaller and automatic breather/drain devices for frames 324T and larger) and upgraded insulation by additional dips and bakes to increase moisture resistance.
- b. Totally enclosed non-ventilated: TENV motors shall include the same rating and accessories as specified for TEFC motors.

J. Special Purpose Motors:

1. Chemical duty motors shall be provided with severe duty rating. Motors shall be of the corrosion resistant type conforming to motors designated by the manufacturer as Corro-Duty, Mill and Chemical, Custom Severe Duty, or similar quality designation. Severe duty motors shall have a cast iron frame, cast iron end brackets, cast iron conduit box and 1.15 service factor at 40 degrees C and tapped drain holes (corrosion resistant plug for frames 286T and smaller and automatic breather/drain devices for frames 324T and larger).
2. Hermetically sealed air conditioning units, elevators, hoists, cranes and other devices complying with special safety codes shall be furnished with motors, control equipment, accessories and safety devices for approved, safe, and efficient operation, in accordance with the manufacturer's standards and to be rated for the duty cycle as specified for the driven equipment. Minimum service factor 1.15 above 3 hp.
3. Submersible motors shall be manufacturer's standard.
4. Synchronous and wound rotor motors shall be specified elsewhere in the specifications when required.
5. Inverter duty rated: Motors for operation on variable frequency drives shall meet current power quality levels published in NEMA MG1, Part 31. Enclosures shall be equal to those furnished for severe duty or explosion proof motors. Motor shaft and bearings shall be insulated. Internal service factor shall be 1.15 that of the nameplate. Ventilation system shall be designed for maximum heat transfer. Stator laminations shall be stagger-stacked and stamped from high grade electrical steel to minimize eddy-current losses and heat build-up caused by inverter induced harmonics. Rotors shall be configured to minimize skin-effect heating.

K. Auxiliary Devices:

1. Three phase motors shall not be provided with starting capacitors.
2. Single-phase motors requiring switching devices and auxiliary starting resistors, capacitors, or reactors shall be furnished as combination units with such auxiliaries either incorporated within the motor housings or housed in suitable enclosures

mounted upon the motor frames. Each combination unit shall be mounted upon a single base and to be provided with a single conduit box.

3. Motors 200 hp or over, or where specified in other sections, shall have built-in overload protection device.
 - a. Winding temperature detectors, shall be factory installed, embedded, bi-metallic switch type or thermistors with relay with leads terminating in the main conduit box. This device shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure. The switch shall have normally closed contacts. Not less than three detectors shall be furnished with each motor.
 - b. Resistance Temperature Detectors (RTD) shall be factory installed with two stator winding RTDs embedded in each phase, total of six, and one RTD for each bearing, total of two. RTDs shall be 3-wire, 100-ohm platinum, and prewired to an auxiliary terminal box on the motor frame. Lead wires shall be stranded copper wire with Dupont Kapton insulation.

L. General Design of Motors:

1. Motors shall comply with the latest NEMA Standards Publication No. MG1 for Motors and Generators, unless otherwise specified.
2. All polyphase non-explosion proof motors shall be designed for energy efficient operation and meet the requirements of MG1-12.53 a and b.
3. Motor windings shall be braced to withstand successfully the stresses resulting from the method of starting. The windings shall be treated thoroughly with acceptable insulating compound suitable for protection against moisture and slightly acid or alkaline conditions.
4. Bearings shall be of the self-lubricating type, designed to ensure proper alignment of rotor and shaft and to prevent leakage of lubricant.
 - a. Bearings for open motors shall be of the sleeve or ball type, as specified under the respective items of mechanical equipment.
 - b. Bearings for totally enclosed and explosionproof motors shall be of the ball type.
 - c. Bearing minimum L-10 fatigue life in hours at 100 percent load shall be 60,000 (unless a greater value is indicated elsewhere in the specifications set).
 - d. Bearing grease shall be of the 120 degrees C thermal capability type.

5. Vertical motors shall be provided with thrust bearings adequate for all thrusts to which they can be subjected in operation.
6. Vertical motors of the open type shall be provided with drip hoods of acceptable shape and construction. When the drip hood is too heavy to be easily removed, provision to be made for access for testing.
7. All three phase two speed motors shall be of the two-winding design.
8. All three phase motors shall be provided with a 1.15 service factor.
9. Three phase motors shall be of cast iron construction including frame and end brackets.
10. Totally enclosed motors shall be provided with automatic breather and drain
11. Motor nameplates shall be stainless steel.
12. Motor Terminal Boxes and Leads:
 - a. Motors shall be furnished with oversize conduit terminal boxes to provide for making and housing the connections, and with flexible leads of sufficient length to extend for a distance of not less than 4 inches beyond the face of the box. The size of cable terminals, and terminal box conduit holes shall be as permitted by the Engineer. An acceptable type of solderless lug to be furnished. Totally enclosed and explosionproof motors to have cast-iron terminal boxes.
 - b. Leads for space heaters and auxiliary devices shall be brought out into an auxiliary, cast, conduit box on the motor side opposite to the main terminal box. Auxiliary box to have 1 inch threaded conduit openings (minimum) and shall be so constructed that conduit entrance may be placed at top, bottom, or either side.
 - c. A grounding terminal shall be provided in the main terminal box and a bronze grounding bolt to be furnished at the conduit side of the motor frame.

M. Motor Efficiencies:

1. Three phase motors rated 1 hp and larger shall be of the premium efficiency, "Design E", type per Table 12.1 of NEMA MG1 Part 12. Motors shall have a NEMA Nominal Efficiency not less than the values referenced in NEMA MG1. Efficiency values shall be based on tests performed in accordance with IEEE Publication No. 112, Method B. Motors with horsepower or rpm's not listed shall conform to comparable standards of construction and materials as those for listed motors.

N. Shop Painting:

1. Unless otherwise specified, motors shall be given a shop application of paint filler or enamel sealer, a flat coat of undercoated for enamel, and two coats of enamel or, in lieu of this treatment, other corrosion-resistant treatment customary with the manufacturer.

O. Motor Data:

1. The Contractor shall furnish the Engineer with five certified copies of characteristic curves of each motor furnished, except 115-volt motors. Curves shall be supplied as a part of the driven equipment submittal.

P. Motor Shop Tests:

1. Motor shop tests shall be made in accordance with the IEEE Test Codes as specified in the NEMA MG1 Standards for Motors and Generators. NEMA report-of-test forms to be used in submitting test data.
2. Motor efficiency shall be determined by use of IEEE Standard 112 Test Method B, and by use of MGI-12.53 a and b.
3. For induction motors larger than 100 hp, complete tests of each motor furnished to be made and certified tests data sheets to be submitted, unless witness shop tests are required by the technical specifications pertaining to the equipment. Each motor shall be tested at rated voltage for: efficiency and power factor at 50, 75, and 100 percent of it rated horsepower; for temperature rise, torque, no-load current, starting current, full load current, and dielectric strength; and for compliance with all specified performance requirements.
4. For induction motors 5 hp, up to and including 100 hp, copies of routine tests reports of electrically duplicate motors shall be furnished.
5. For motors 3 hp or less, no test data need be furnished.

Q. Spare Parts:

1. Provide in accordance with Section 01 61 00 and as specified.
2. Furnish one spare bearing of each type for each motor size and type.

2.04 ELECTRICAL INTERFACE

- A. All items of electrical equipment that are furnished with process, heating, ventilating, or other equipment shall conform to the requirements specified under the applicable electrical sections of the Division 26 specifications. Enclosures for electrical equipment such as switches, starters, etc., shall also conform to the requirements specified under the applicable electrical sections of the Division 26 specifications.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Verify heaters are energized on motors installed in outdoor or unheated areas.
- B. After motor installation but before connection to power wiring, test motor winding insulation in accordance with the applicable Division 26 requirements.
- C. After connection to power wiring, check for operating temperature, correct rotation, vibration, alignment and operating current drawn under load.
- D. Submit all motor test results for review and record.

3.02 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 22 14

DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide copper-wound, dry-type transformers as indicated and in compliance with Contract Documents.
- B. Provide transformer windings and enclosures rated for the installation location and in accordance with the requirements herein.
- C. Transformers shall be “Energy Star” rated.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. Z55.1: Gray Finishes for Industrial Apparatus and Equipment
- B. ASTM International (ASTM):
 - 1. D635: Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. ST 20: Dry-Type Transformers for General Applications (ANSI C89.2) - withdrawn
- D. International Electrical Testing Association (NETA):
 - 1. ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- E. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
- F. Underwriters' Laboratories, Inc. (UL):
 - 1. 506: Standard for Specialty Transformers.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Submit shop drawings and manufacturer's product data of the transformer. Information to include:
 - 1. Outline drawings including dimensions.
 - 2. Weight.
 - 3. Ratings and tap configuration.
 - 4. Core and coil material.
 - 5. Insulation system description.
 - 6. Loss data and efficiency.
 - 7. Accessories.
 - 8. Mounting requirements.
 - 9. Nameplate data.
 - 10. Testing data.
- C. Submit a Certificate of Compliance indicating conformance to the Seismic Requirements specified. Certificate shall be signed and sealed by a Professional Structural Engineer holding current registration in the state for work of this project.

1.04 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements specified in Section 01 41 20.
- B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Provide in accordance with Section 01 66 10 "Deliver, Storage and Handling".
- B. Deliver transformers individually wrapped for protection and mounted on shipping skids.

- C. Accept transformers on site. Inspect for damage.
- D. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle and stored in accordance with manufacturer's written instructions. Lift only with lugs provided. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

1.07 REQUIREMENTS OF REGULATORY AGENCIES

- A. Furnish transformers in accordance with NEMA ST 20 and UL 506.
- B. Furnish transformers with UL listing mark.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Square D Co.
- B. Siemens Inc.
- C. General Electric Company.

2.02 TRANSFORMERS

- A. In NEMA 1 and NEMA 12 designated areas, furnish general purpose, ventilated, dry-type transformers in indoor-style enclosure. On single-phase transformers and three-phase transformers above 9 KVA, provide not less than two windings per phase.
 - 1. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
 - 2. Ventilation openings shall prevent accidental access to live components.
 - 3. Thoroughly clean and paint enclosure at the factory with manufacturer's prime coat and standard finish.
- B. In NEMA 4 or NEMA 4X designated areas, provide transformers with encapsulated windings and stainless-steel enclosures.
- C. Auto transformers shall not be used in place of general purpose dry-type transformers.
- D. Furnish at least two 2-1/2 percent full capacity taps above and below nominal in high voltage winding for transformers rated above 15 kVA. Two five percent taps below rated voltage for transformers rated 15 kVA and below.

- E. Furnish transformers, single-phase or three-phase, as indicated. Furnish transformers with kVA ratings as indicated.
- F. Furnish three-phase transformers, Delta-Wye connected as indicated, and conforming to latest NEMA standards. Scott Tee connected transformers are not acceptable above 9 kVA.
- G. Isolate core and coil from enclosure using vibration-absorbing mounts.
- H. Furnish transformers with primary and secondary voltages and frequency, wye connected, as indicated for secondary windings, with neutral brought out for cable termination.
- I. Furnish transformers designed for continuous operation at rated kVA with normal life expectancy as defined in NEMA ST 20.
- J. For transformers rated 30 kVA or less, ensure that performance is obtained without exceeding 115 degrees C average temperature rise by resistance or 145 degrees C hot spot temperature rise in 40 degrees C maximum ambient and 30 degrees C average ambient. Do not allow maximum coil hot spot temperature to exceed 185 degrees C.
- K. Furnish transformers with 220 degrees C insulation materials with proven reliability for 15 kVA transformers and above. Furnish 185 degrees C insulation on transformers below 15 kVA.
- L. Transformers rated greater than 30 kVA shall be provided with low-loss 80 degrees C full load operating temperature rise rating.
- M. Furnish transformers made of flame-retardant materials that will not support combustion as defined in ASTM D635.
- N. Furnish core mounting frames and enclosures of welded and bolted construction with mechanical rigidity and strength to withstand shipping, erection and short circuit stresses.
 - 1. Cores shall be grain oriented, non-aging, and silicon steel.
 - 2. Coils shall be continuous windings without splices except for tapes.
 - 3. Coil loss and core loss shall be minimum for efficient operation.
 - 4. Primary and secondary tap connections shall be razed or pressure type.
 - 5. Coil windings shall have end fillers or tie downs for maximum strength.
- O. Transformers located in areas where fire protection system sprinklers are located shall be provided with NEMA 2 rated enclosure to protect transformer from water falling at an angle of 75 degrees from the vertical.
- P. Furnish transformers designed to meet UL thermal overload test of 200 percent of rated current for one half hour.

- Q. Furnish transformers not to exceed the 65 degrees C rise established by UL as safe limit for maximum surface enclosure temperature.
- R. Furnish transformers with sound level not exceeding:

Average Sound Level in dB

kVA	NEMA ST 20
0-09	40
10-50	45
51-150	50
151-300	55
301-500	60

- S. Install transformers with sound levels greater than 50 dB on resilient vibration isolating mounts to prevent amplification of sound. Transformers rated 15 kVA and larger to be provided with rubber washer anti-vibration pads and molded neoprene assemblies to isolate noise from the transformer to the mounting surface.

2.03 SHOP TESTING

- A. Submit results of audible-sound-levels tests in accordance with NEMA ST 20 of similar size transformer.
- B. Production test each unit in accordance with NEMA ST 20.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Set transformer plumb and level. Install and guard transformers as specified by latest NEC and ANSI standards, and in accordance with manufacturer's printed instructions.
- B. Furnish adequate space around transformer to dispose of transformer full load losses by ventilation without creating excessive ambient temperature. Verify working clearances as required by the NEC are met.
- C. Unless indicated otherwise on drawings, wall mount with suitable supports, transformers rated 15 kVA and below. Floor mount transformers rated above 15 kVA unless otherwise indicated on the drawings. In addition, all transformers located in NEMA 4 or NEMA 4X designated areas shall be wall mounted on Type 316 stainless steel channel supporting systems with Type 316 stainless steel concrete inserts, minimum 7 feet-6 inches (2.3 m) AFF. Provide all required seismic restraints.
- D. Provide lifting lugs and jacking plates on transformer enclosure.

- E. Provide concrete pad for all floor mounted transformers.
- F. Clean metal parts, excepting cores and core mounting frames, then rust-proof and apply heavy coating of inert primer. Paint coverplates and external metal parts with two finish coats of ANSI Z55.1 No. 61 or 49 Gray.
- G. Verify mounting pads are in place to reduce noise.
- H. Install grounding and bonding in accordance with the drawings and Section 26 05 26 “Grounding and Bonding for Electrical Systems”.

3.02 FIELD TESTING

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.2.1.

3.03 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 24 13

LOW-VOLTAGE SWITCHBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide a 480 volt, 3-phase, 4-wire, electrical distribution rated switchboard, free-standing construction with circuit breakers, power monitor, distribution class lightning arrestors, surge arrestors, automatic transfer switch, and group-mounted circuit breakers as indicated and in compliance with Contract Documents.
- B. Provide services of a factory-trained service engineers, specifically trained to check connections, interwiring to equipment, adjustments and assisting in tests.
 - 1. Provide guidance during installation to check work of installing contractor.
 - 2. Instruct personnel in care and operation of equipment.
 - 3. Test main breaker and all branch breakers including spares; insure proper setting.
 - 4. Inspect installation and adjust as necessary when switchboard is ready to be energized and put into service.
 - 5. Test ground fault system and set all protective devices.
 - 6. Certify that equipment has been inspected and is ready to be placed into service.

1.02 REFERENCES

- A. Federal Specifications (FS):
 - 1. QQ-S-365B: General Requirements for Silver Plating, Electro Deposited
 - 2. W-C-375: Molded Case Circuit Breakers.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 - 2. PB-2: Switchboards.
- C. Underwriter's Laboratories (UL):
 - 1. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

2. 91: Switchboards.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Manufacturer's certified shop drawings including outlines, schematics and wiring diagrams, coordination curves, certified test data reports, maintenance data, operating instructions and parts list with list of recommended spare parts.
- C. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements specified in Section 01 41 20.
- B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.
- B. Provide spare parts as recommended by manufacturer.
- C. Package spare equipment in containers bearing labels clearly indicating contents and in what equipment used.
- D. Deliver spare parts at same time as equipment. Properly store and safeguard such spare parts until completion of work, at which time deliver to Owner.

1.06 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00 "Quality Requirements".
- B. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier prior to installation.
- C. Single-source Responsibility: Provide switchboard products that are new, and from the same manufacturer for each building or job. Switchboard components shall be from the same manufacturer or listed as an assembly thereof.
- D. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive

maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.

E. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Times listed are for each switchboard.
2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment and field erection:
 - a. 2 person-days
3. Functional Testing: Check alignment and perform a functional test. Tests to include all items specified.
 - a. 2 person-days
4. Testing: Field performance test equipment specified.
 - a. 2 person-days
5. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
6. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
 - a. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:
 - (1) 1 person-day - switchboard

1.07 DELIVERY AND STORAGE

A. Shipping:

1. Ship equipment, and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
3. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.
4. Channel bases:
 - a. For front and rear, minimum of 1-1/2 inch (37 mm) by 3 inch (74 mm) standard channel with suitable holes for mounting switchboard, and holes for grouting and flow of concrete.
 - b. Shipped in advance with accurate template of switchboard mounting holes or dimension layout drawing for embedding in concrete pad, floor slab, or securing to floor. Coordinate with all contractors.
5. Attach lifting angles to main frame of structure to distribute weight equally. Deflection or distortion is cause for rejection.
6. Provide heavy plastic envelope directly over switchboard to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

B. Storage:

1. Inspection and inventory items upon delivery to site.
2. Store and safeguard equipment, material and spare parts.

1.08 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard that fail in materials or workmanship within specified warranty period.
1. Switchboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers acceptable contingent upon products' compliance with the specifications:
1. Eaton
 2. ABB
 3. Siemens Corp.
 4. Schneider/Square D.

2.02 SWITCHBOARD EQUIPMENT

A. Structure:

1. Totally enclosed switchboard dead front, free standing, front and rear aligned with front accessibility only required.
2. General purpose switchboard with frame-work of UL gauge formed steel and channels and secured together to support all cover plates, bussing and component devices during shipment and installation. Formed removable closure plates on the front, rear and sides. Closure plates shall be single tool, screw removable.
3. Refer to contract documents for NEMA enclosure type.
4. Ventilation provided when required.
5. Each section includes a single-piece removable top plate.

B. Incoming Line; devoted to the main service entrance utility supply.

1. Utility line section consists of:
 - a. Device:
 - (1) Main RMS sensing, disconnect device shall be a solid state, true RMS adjustable trip, insulated case, circuit breaker. The main breaker shall be provided fixed style.
 - (2) In conjunction with the main device, provide undervoltage capacitor trip, phase failure and phase reversal protection, alarm switch, auxiliary switches, long time, short time, instantaneous trip and selective coordination ground fault protection with downstream ground fault protective devices.
 - (3) Provide “push to trip” push button on circuit breaker to allow manual trip with risking exposure to live parts.
 - (4) Provide trip indicator to identify type of fault, and indicate OVERLOAD, SHORT CIRCUIT or GROUND FAULT on display.
 - (5) Main breaker to be provided with capability of locking in the open position.
 - (6) The trip unit shall include local setup and readout of trip settings and digital display metering of:
 - (a) 3-phase volts
 - (b) frequency

- (c) KW
 - (d) KVA
 - (e) amps
- b. Cable termination suitable for cable entry from below, located at bottom section.
- c. Line side terminals fitted with two-hole, compression-type lugs for four copper cable conductors per phase.
- d. Provide section for Utility service meter and CTs. Verify size of section with Utility equipment.
- e. Tinned bus of suitable rating and bracing.
- f. Tinned copper ground bus 1/4-inch x 2 inch (6 mm x 50 mm) extended and tied through to all adjoining sections.

C. Power Monitor:

- 1. Provide microprocessor-based monitoring device to provide local and remote monitoring of the electrical system.
 - a. Voltage input of 120 volts using voltage transformers.
 - b. Current input from current transformers, phase A, B, C and ground.
- 2. Comply with ANSI C12.16, Class 10.
- 3. Display data:
 - a. Current A, B, C, Average, Neutral, Ground.
 - b. Voltage - Phase to phase
 - (1) Phase to neutral
 - (2) Phase to ground
 - (3) Average values
 - c. Power - Watts
 - (1) Vars
 - (2) VA

- (3) Phases A, B, C and System
 - d. Energy - KWH
 - (1) KVARH
 - e. Frequency
 - f. Demand - System current
 - (1) KW
 - (2) KVAR
 - (3) KVA
 - g. Power Factor - Phases A, B, C, System
 - h. Percent THD Current - Phases A, B, C, N
 - i. Percent THD Voltage:
 - (1) Phase to phase
 - (2) Phase to neutral
 - j. Minimum and maximum values
 - k. Monitor past events and thresholds.
- 4. Provide power monitor with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.
- D. Group Mounted Branch Sections:
 - 1. The switchboard group-mounted circuit breaker branch devices shall be totally front accessible and front connectable.
 - 2. The circuit breaker connections to the distribution panel bussing shall be such that the connections grip the bus bars firmly under high-fault conditions.
 - 3. Provide wiring gutters of sufficient space to allow cable termination.
 - 4. Provide covers for gutter space and future breaker space with formed sheet steel.
 - 5. Provide circuit breakers as indicated on the one-line diagram.
- E. Enclosure - General Requirements:

1. Switchboard shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard 90 inch (2.29 m) high.
2. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure.
3. The frame structure members shall be die-formed, 12-gage steel bolted together and reinforced at corners with rugged gussets internal and external to the structure members.
4. The switchboard shall be completely front accessible for all installation and maintenance activities.
5. At the main service entrance section, the sheet steel panels located on the exterior and side of the section shall be removable for servicing the section.
6. The switchboard frame shall be mounted to sills embedded in a concrete housekeeping pad.
7. The switchboard and devices are fully rated at minimum short circuit rating of 65,000 rms symmetrical Amperes. Refer to contract documents for additional requirements.
8. Switchboard shall include all protective devices depicted on contract drawings and as specified in these specifications with necessary interconnection, instrumentation and control wiring.
9. Main breaker shall be individually mounted.
10. All buses are tin plated copper, supported with high impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions. All bus connections shall utilize silver plated bus bar surfaces.
11. The current density of the bus shall be determined from UL-891 heat rise testing and shall be rated for 1000 amperes per square inch cross-section.
12. A tinned copper, 1/4-inch x 2 inch (6 mm x 50 mm) ground bus shall furnished and secured to structure.
13. A-B-C type bus arrangement (left-to-right, top-to-bottom, front-to-rear) is to be used throughout to assure convenient and safe testing and maintenance.
14. The vertical main bus bars are furnished for future branch devices. Device mounting bolts and bus connecting straps are supplied with future unit devices. Full height bus bars shall be supplied.
15. All vertical sections comprising the switchboard are rear-aligned.

16. All steel surfaces shall be chemically cleaned and pre-treated with an iron-phosphate pre-treatment or equivalent process, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and formation of rust under the paint. The switchboard exterior shall be finished with ANSI-61 light gray paint. Provide touch-up paint for coatings nicks and scratches after installation and testing.
17. Control wiring, fuse blocks and terminal blocks within the switchboard shall be furnished when required. All control wires leaving the switchboard shall be provided with terminal blocks with numbering strips.
18. All hardware used on conductors shall have a high tensile strength, and a protective finish.
19. Switchboard shall be provided with lifting means, and capable of being rolled or moved into installation position and bolted directly to floor sills.
20. Make provision for conduit and cable entrance from top or bottom as indicated on the drawings.

2.03 SWITCHBOARD SILLS

- A. Provide steel channel sills with drilled holes for mounting, aligning and bolting switchboard in place. Method of mounting as indicated. Provide in size recommended by switchboard manufacturer and acceptable to Engineer.
- B. Shop paint completed sills with two coats of a polyamide epoxy coating with a minimum dry film thickness of 2.5 mils (0.6 mm) per coat or before setting in place.
 1. Surface preparation shall conform to paint manufacturer's printed instructions.
 2. Provide additional coating for field touch-up specified in paragraph 3.01.

2.04 SWITCHBOARD INSTRUMENT TRANSFORMERS

- A. Switchboard section for main breaker shall include three 480 to 120-volt potential transformers, and one 480 to 120/240 volt single phase control power transformer. Control and potential transformers to be connected ahead of main circuit breaker and to include current limiting primary fuses. Mount transformers in isolated compartment within secondary bus transition section. Also provide, on main bus for each main breaker four window type 3000/5A current transformers for metering phase and neutral current and one 200/5A current for monitoring ground currents.
- B. Tie all instrument transformer outputs to power monitor.

2.05 FEEDER PROTECTIVE DEVICES

- A. All feeder protective devices shall be molded case circuit breakers with inverse time tripping characteristics as indicated on the contract documents and in this specification.

- B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
- C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the contract documents.
- D. Circuit breakers to be either draw-out or fixed mounted, as indicated on contract documents
- E. Circuit breakers shall have microprocessor-based rms sensing trip units as specified below:
 - 1. All electronic trip molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.
 - 2. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The breakers shall have an input for an external switch to set in arc flash reduction mode. Provide a blue LED indicating light on front of enclosure to indicate in arc flash reduction mode. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.
 - 3. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:
 - a. Adjustable long-delay pick-up setting with minimum of 10 settings
 - b. Adjustable long-delay time - 0.5 to 24 seconds
 - c. Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame
 - d. Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I²t curve shaping
 - e. Adjustable instantaneous setting 2x to Max allowable by frame
 - f. Where indicated, adjustable ground fault current pickup (0.2 – 1.0 x I_n in 0.10x increments) and time (0.1 – 1.0 sec in 0.10 sec increments), with selectable flat or I²t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.

4. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.
5. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.
 - a. Number of operations (load and no-load)
 - b. Number of trips (overload trips, short circuit trips)
 - c. Run time
 - d. Breaker ambient temperature.
 - e. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.
 - f. All breaker health information shall be accessible via micro-USB port on front of trip unit and via embedded communications
6. Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.
 - a. Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.
 - b. Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.
 - c. Waveform events shall capture and store all phase, neutral and ground currents.

2.06 SWITCHBOARD FACTORY TESTS

- A. The switchboard shall be completely assembled, wired, adjusted, temporarily powered and tested at the factory. Provide test results for acceptance.
- B. The fully assembled switchboard shall be given operational, dielectric, and all other standard tests.

2.07 MISCELLANEOUS DEVICES

- A. Kirk Key interlocks shall be provided as indicated on the drawings.
- B. Arc Flash Reduction Maintenance Switch

1. Provide switch where indicated on the plans or one-line diagrams.
2. Provide selector switch which illuminates BLUE when engaged.
3. Switch shall have a flip-up cover to operate.
4. Switch shall be NEMA 4X rated.
5. Provide label to read "Maintenance Mode" on top with "ON" and "OFF" indication. Label to read "Arc Flash Reduction Maintenance Switch" on bottom.

- C. Provide external Surge Protection Devices as indicated on the drawings. Reference Section 26 43 00 "Surge Protection Devices" for requirements.

2.08 WIRING

- A. Conductors: Copper; size as required by load, except that no control wire is smaller than 14 AWG. Use insulation that is flame retardant, and moisture and heat resistant.
- B. Cables and conductors: Bundled and tie wrapped securely in wireways furnished.
- C. Identify internal wiring at terminations by T&B wire markers or equivalent.
- D. All spare auxiliary contacts shall be wired to terminal blocks.
- E. Terminal Blocks:
 1. Rated 600 volt for power with current rating as required by loads.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. After inspection, and prior to energizing, provide 250 watts of heat within each Section.
- B. Install equipment in accordance with manufacturer's printed instructions and as indicated and specified. Install equipment on channels set flush with floor or on concrete bases. Interconnect equipment as a complete operating system.
 1. After installation, field touch-up the shop painting finish on the channels with a similar and compatible coating, including color.
- C. Have installed equipment field-checked by manufacturer's service engineer, who perform following services:
 1. Check installed equipment for proper assembly and connections, including interwiring to external equipment.

2. Set adjustable devices per the approved electrical coordination study.
3. Assist Contractor in conducting equipment acceptance tests.

3.02 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.
- B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.03 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 1. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- C. Tests and Inspections:
 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:

- (1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Switchboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.04 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 24 13

LOW-VOLTAGE SWITCHBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide a 480 volt, 3-phase, 4-wire, electrical distribution rated switchboard, free-standing construction with circuit breakers, power monitor, distribution class lightning arrestors, surge arrestors, automatic transfer switch, and group-mounted circuit breakers as indicated and in compliance with Contract Documents.
- B. Provide services of a factory-trained service engineers, specifically trained to check connections, interwiring to equipment, adjustments and assisting in tests.
 - 1. Provide guidance during installation to check work of installing contractor.
 - 2. Instruct personnel in care and operation of equipment.
 - 3. Test main breaker and all branch breakers including spares; insure proper setting.
 - 4. Inspect installation and adjust as necessary when switchboard is ready to be energized and put into service.
 - 5. Test ground fault system and set all protective devices.
 - 6. Certify that equipment has been inspected and is ready to be placed into service.

1.02 REFERENCES

- A. Federal Specifications (FS):
 - 1. QQ-S-365B: General Requirements for Silver Plating, Electro Deposited
 - 2. W-C-375: Molded Case Circuit Breakers.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 - 2. PB-2: Switchboards.
- C. Underwriter's Laboratories (UL):
 - 1. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

2. 91: Switchboards.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Manufacturer's certified shop drawings including outlines, schematics and wiring diagrams, coordination curves, certified test data reports, maintenance data, operating instructions and parts list with list of recommended spare parts.
- C. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements specified in Section 01 41 20.
- B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 SPARE PARTS

- A. Comply with the requirements specified in Section 01 31 00 "Project Management and Coordination Requirements".
- B. Provide spare parts as recommended by manufacturer.
- C. Package spare equipment in containers bearing labels clearly indicating contents and in what equipment used.
- D. Deliver spare parts at same time as equipment. Properly store and safeguard such spare parts until completion of work, at which time deliver to Owner.

1.06 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00 "Quality Requirements".
- B. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier prior to installation.
- C. Single-source Responsibility: Provide switchboard products that are new, and from the same manufacturer for each building or job. Switchboard components shall be from the same manufacturer or listed as an assembly thereof.

- D. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.
- E. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Times listed are for each switchboard.
 - 2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment and field erection:
 - a. 2 person-days
 - 3. Functional Testing: Check alignment and perform a functional test. Tests to include all items specified.
 - a. 2 person-days
 - 4. Testing: Field performance test equipment specified.
 - a. 2 person-days
 - 5. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 - 6. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
 - a. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:
 - (1) 1 person-day - switchboard

1.07 DELIVERY AND STORAGE

- A. Shipping:

1. Ship equipment, and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.
2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
3. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.
4. Channel bases:
 - a. For front and rear, minimum of 1-1/2 inch (37 mm) by 3 inch (74 mm) standard channel with suitable holes for mounting switchboard, and holes for grouting and flow of concrete.
 - b. Shipped in advance with accurate template of switchboard mounting holes or dimension layout drawing for embedding in concrete pad, floor slab, or securing to floor. Coordinate with all contractors.
5. Attach lifting angles to main frame of structure to distribute weight equally. Deflection or distortion is cause for rejection.
6. Provide heavy plastic envelope directly over switchboard to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

B. Storage:

1. Inspection and inventory items upon delivery to site.
2. Store and safeguard equipment, material and spare parts.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard that fail in materials or workmanship within specified warranty period.

1. Switchboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers acceptable contingent upon products' compliance with the specifications:

1. Eaton
2. ABB

3. Siemens Corp.
4. Schneider/Square D.

2.02 SWITCHBOARD EQUIPMENT

A. Structure:

1. Totally enclosed switchboard dead front, free standing, front and rear aligned with front accessibility only required.
2. General purpose switchboard with frame-work of UL gauge formed steel and channels and secured together to support all cover plates, bussing and component devices during shipment and installation. Formed removable closure plates on the front, rear and sides. Closure plates shall be single tool, screw removable.
3. Refer to contract documents for NEMA enclosure type.
4. Ventilation provided when required.
5. Each section includes a single-piece removable top plate.

B. Incoming Line; devoted to the main service entrance utility supply.

1. Utility line section consists of:
 - a. Device:
 - (1) Main RMS sensing, disconnect device shall be a solid state, true RMS adjustable trip, insulated case, circuit breaker. The main breaker shall be provided fixed style.
 - (2) In conjunction with the main device, provide undervoltage capacitor trip, phase failure and phase reversal protection, alarm switch, auxiliary switches, long time, short time, instantaneous trip and selective coordination ground fault protection with downstream ground fault protective devices.
 - (3) Provide “push to trip” push button on circuit breaker to allow manual trip with risking exposure to live parts.
 - (4) Provide trip indicator to identify type of fault, and indicate OVERLOAD, SHORT CIRCUIT or GROUND FAULT on display.
 - (5) Main breaker to be provided with capability of locking in the open position.
 - (6) The trip unit shall include local setup and readout of trip settings and digital display metering of:

- (a) 3-phase volts
 - (b) frequency
 - (c) KW
 - (d) KVA
 - (e) amps
- b. Cable termination suitable for cable entry from below, located at bottom section.
- c. Line side terminals fitted with two-hole, compression-type lugs for four copper cable conductors per phase.
- d. Provide section for Utility service meter and CTs. Verify size of section with Utility equipment.
- e. Tinned bus of suitable rating and bracing.
- f. Tinned copper ground bus 1/4-inch x 2 inch (6 mm x 50 mm) extended and tied through to all adjoining sections.

C. Power Monitor:

- 1. Provide microprocessor-based monitoring device to provide local and remote monitoring of the electrical system.
 - a. Voltage input of 120 volts using voltage transformers.
 - b. Current input from current transformers, phase A, B, C and ground.
- 2. Comply with ANSI C12.16, Class 10.
- 3. Display data:
 - a. Current A, B, C, Average, Neutral, Ground.
 - b. Voltage - Phase to phase
 - (1) Phase to neutral
 - (2) 2) Phase to ground
 - (3) 3) Average values
 - c. Power - Watts

- (1) Vars
 - (2) VA
 - (3) Phases A, B, C and System
- d. Energy - KWH
 - (1) KVARH
- e. Frequency
- f. Demand - System current
 - (1) KW
 - (2) KVAR
 - (3) KVA
- g. Power Factor - Phases A, B, C, System
- h. Percent THD Current - Phases A, B, C, N
- i. Percent THD Voltage:
 - (1) Phase to phase
 - (2) Phase to neutral
- j. Minimum and maximum values
- k. Monitor past events and thresholds.
- 4. Provide power monitor with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.

D. Group Mounted Branch Sections:

- 1. The switchboard group-mounted circuit breaker branch devices shall be totally front accessible and front connectable.
- 2. The circuit breaker connections to the distribution panel bussing shall be such that the connections grip the bus bars firmly under high-fault conditions.
- 3. Provide wiring gutters of sufficient space to allow cable termination.
- 4. Provide covers for gutter space and future breaker space with formed sheet steel.

5. Provide circuit breakers as indicated on the one-line diagram.

E. Enclosure - General Requirements:

1. Switchboard shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard 90 inch (2.29 m) high.
2. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure.
3. The frame structure members shall be die-formed, 12-gage steel bolted together and reinforced at corners with rugged gussets internal and external to the structure members.
4. The switchboard shall be completely front accessible for all installation and maintenance activities.
5. At the main service entrance section, the sheet steel panels located on the exterior and side of the section shall be removable for servicing the section.
6. The switchboard frame shall be mounted to sills embedded in a concrete housekeeping pad.
7. The switchboard and devices are fully rated at minimum short circuit rating of 65,000 rms symmetrical Amperes. Refer to contract documents for additional requirements.
8. Switchboard shall include all protective devices depicted on contract drawings and as specified in these specifications with necessary interconnection, instrumentation and control wiring.
9. Main breaker shall be individually mounted.
10. All buses are tin plated copper, supported with high impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions. All bus connections shall utilize silver plated bus bar surfaces.
11. The current density of the bus shall be determined from UL-891 heat rise testing and shall be rated for 1000 amperes per square inch cross-section.
12. A tinned copper, 1/4-inch x 2 inch (6 mm x 50 mm) ground bus shall furnished and secured to structure.
13. A-B-C type bus arrangement (left-to-right, top-to-bottom, front-to-rear) is to be used throughout to assure convenient and safe testing and maintenance.

14. The vertical main bus bars are furnished for future branch devices. Device mounting bolts and bus connecting straps are supplied with future unit devices. Full height bus bars shall be supplied.
15. All vertical sections comprising the switchboard are rear-aligned.
16. All steel surfaces shall be chemically cleaned and pre-treated with an iron-phosphate pre-treatment or equivalent process, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and formation of rust under the paint. The switchboard exterior shall be finished with ANSI-61 light gray paint. Provide touch-up paint for coatings nicks and scratches after installation and testing.
17. Control wiring, fuse blocks and terminal blocks within the switchboard shall be furnished when required. All control wires leaving the switchboard shall be provided with terminal blocks with numbering strips.
18. All hardware used on conductors shall have a high tensile strength, and a protective finish.
19. Switchboard shall be provided with lifting means, and capable of being rolled or moved into installation position and bolted directly to floor sills.
20. Make provision for conduit and cable entrance from top or bottom as indicated on the drawings.

2.03 SWITCHBOARD SILLS

- A. Provide steel channel sills with drilled holes for mounting, aligning and bolting switchboard in place. Method of mounting as indicated. Provide in size recommended by switchboard manufacturer and acceptable to Engineer.
- B. Shop paint completed sills with two coats of a polyamide epoxy coating with a minimum dry film thickness of 2.5 mils (0.6 mm) per coat or before setting in place.
 1. Surface preparation shall conform to paint manufacturer's printed instructions.
 2. Provide additional coating for field touch-up specified in paragraph 3.01.

2.04 SWITCHBOARD INSTRUMENT TRANSFORMERS

- A. Switchboard section for main breaker shall include three 480 to 120-volt potential transformers, and one 480 to 120/240 volt single phase control power transformer. Control and potential transformers to be connected ahead of main circuit breaker and to include current limiting primary fuses. Mount transformers in isolated compartment within secondary bus transition section. Also provide, on main bus for each main breaker four window type 3000/5A current transformers for metering phase and neutral current and one 200/5A current for monitoring ground currents.

- B. Tie all instrument transformer outputs to power monitor.

2.05 FEEDER PROTECTIVE DEVICES

- A. All feeder protective devices shall be molded case circuit breakers with inverse time tripping characteristics as indicated on the contract documents and in this specification.
- B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
- C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the contract documents.
- D. Circuit breakers to be either draw-out or fixed mounted, as indicated on contract documents
- E. Circuit breakers shall have microprocessor-based rms sensing trip units as specified below:
 - 1. All electronic trip molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.
 - 2. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The breakers shall have an input for an external switch to set in arc flash reduction mode. Provide a blue LED indicating light on front of enclosure to indicate in arc flash reduction mode. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.
 - 3. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:
 - a. Adjustable long-delay pick-up setting with minimum of 10 settings
 - b. Adjustable long-delay time - 0.5 to 24 seconds
 - c. Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame
 - d. Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping
 - e. Adjustable instantaneous setting 2x to Max allowable by frame

- f. Where indicated, adjustable ground fault current pickup ($0.2 - 1.0 \times I_n$ in 0.10x increments) and time (0.1 – 1.0 sec in 0.10 sec increments), with selectable flat or I²t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.
- 4. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.
- 5. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.
 - a. Number of operations (load and no-load)
 - b. Number of trips (overload trips, short circuit trips)
 - c. Run time
 - d. Breaker ambient temperature.
 - e. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.
 - f. All breaker health information shall be accessible via micro-USB port on front of trip unit and via embedded communications
- 6. Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.
 - a. Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.
 - b. Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.
 - c. Waveform events shall capture and store all phase, neutral and ground currents.

2.06 SWITCHBOARD FACTORY TESTS

- A. The switchboard shall be completely assembled, wired, adjusted, temporarily powered and tested at the factory. Provide test results for acceptance.
- B. The fully assembled switchboard shall be given operational, dielectric, and all other standard tests.

2.07 MISCELLANEOUS DEVICES

- A. Kirk Key interlocks shall be provided as indicated on the drawings.
- B. Arc Flash Reduction Maintenance Switch
 - 1. Provide switch where indicated on the plans or one-line diagrams.
 - 2. Provide selector switch which illuminates BLUE when engaged.
 - 3. Switch shall have a flip-up cover to operate.
 - 4. Switch shall be NEMA 4X rated.
 - 5. Provide label to read "Maintenance Mode" on top with "ON" and "OFF" indication. Label to read "Arc Flash Reduction Maintenance Switch" on bottom.
- C. Provide internally Surge Protection Devices as indicated on the drawings. Reference Section 26 43 00 "Surge Protection Devices" for requirements.

2.08 WIRING

- A. Conductors: Copper; size as required by load, except that no control wire is smaller than 14 AWG. Use insulation that is flame retardant, and moisture and heat resistant.
- B. Cables and conductors: Bundled and tie wrapped securely in wireways furnished.
- C. Identify internal wiring at terminations by T&B wire markers or equivalent.
- D. All spare auxiliary contacts shall be wired to terminal blocks.
- E. Terminal Blocks:
 - 1. Rated 600 volt for power with current rating as required by loads.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. After inspection, and prior to energizing, provide 250 watts of heat within each Section.
- B. Install equipment in accordance with manufacturer's printed instructions and as indicated and specified. Install equipment on channels set flush with floor or on concrete bases. Interconnect equipment as a complete operating system.
 - 1. After installation, field touch-up the shop painting finish on the channels with a similar and compatible coating, including color.

- C. Have installed equipment field-checked by manufacturer's service engineer, who perform following services:
 - 1. Check installed equipment for proper assembly and connections, including interwiring to external equipment.
 - 2. Set adjustable devices per the approved electrical coordination study.
 - 3. Assist Contractor in conducting equipment acceptance tests.

3.02 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.
- B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.03 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard.

Remove front panels so joints and connections are accessible to portable scanner.

- b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
- c. Instruments and Equipment:
 - (1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Switchboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 24 19

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide motor control center, totally enclosed, free-standing, cabinet-type structure with motor starters, circuit breakers and/or fused switches and other equipment, as indicated and specified. Motor control center to operate at 480-volt, 3-phase, 4-wire, 60-Hertz as indicated and in compliance with Contract Documents.
- B. Complete motor control center to be designed, assembled, wired, and tested at the point of manufacture in accordance with the latest NEMA, UL, and ANSI standards.
- C. Use manufacturer's standard when data is not specified.
- D. Provide Surge Protection Devices (SPD) as indicated, and as specified in Section 26 43 00 "Surge Protection Devices".

1.02 REFERENCES

- A. General:
 - 1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
 - 2. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the "date of record" for the Work shall be considered the effective code or standard for the duration of the project.
 - 3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
 - 4. Refer to specific Division 26 Sections for additional referenced codes and standards.
- B. American National Standards Institute (ANSI):
 - 1. C39.1: Electrical Analog Indicating Instruments
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. C57.13: Standard Requirements for Instrument Transformers

- D. National Electrical Manufacturers Association (NEMA):
 - 1. AB 1: Molded Case Breakers
 - 2. ICS 2: Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - 3. KS 1: Enclosed Switches
- E. National Fire Protection Association (NFPA):
 - 1. 70: National Electric Code (NEC).
- F. Underwriters' Laboratories, Inc. (UL):
 - 1. 489: Molded-Case Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
 - 2. 508: Industrial Control Equipment.
 - 3. 845: Standards for Motor Control Centers
 - 4. 1008: Standard for Automatic Transfer Switches
 - 5. 1066: Low Voltage AC and DC Power Circuit Breakers Used in Enclosures
- G. Electrical Safety Program, Electrical Equipment Safety Program, and Lockout/Tagout Program of NTMWD.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10.
- B. Complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, installation instructions.
- C. Complete wiring and schematic diagrams for the equipment furnished. Each wiring diagram shall be legible and not reduced from the original design drafted format. Provide a list of equipment on each wiring diagram for which it is applicable.
- D. Equipment layout.
- E. Time versus current curves for protective devices.
- F. Data sheets for all devices provided as part of the assembly.
- G. All other details required to demonstrate that system has been coordinated and will properly function as a unit.

- H. Spare Parts Data: Provide a list of recommended spare parts for the material and equipment to be provided, including current unit prices and source of supply (indicate which supplies are furnished at no extra cost with purchase of equipment) and in accordance with Section 01 78 23 "Operation and Maintenance Data".
 - I. Operating and Maintenance Instruction Manuals:
 - 1. Furnish:
 - a. Operating instruction manuals outlining step-by-step procedures required for system startup and operation and in accordance with Section 01 78 23 "Operation and Maintenance Data".
 - b. Manufacturer's name, model number, service manual parts list.
 - c. Brief description of equipment and basic operating features.
 - d. Maintenance instruction manuals outlining maintenance procedures, for all devices, including compartment installation, circuit breakers, motor starters and fuses.
 - e. Troubleshooting guide listing possible breakdown and repairs.
 - f. As-built wiring diagrams for the system.
 - J. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final position of controls.
 - K. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- 1.04 SEISMIC DESIGN REQUIREMENTS:
- A. Conform to the requirements specified in Section 01 41 20.
 - B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.
- 1.05 QUALITY ASSURANCE
- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.
 - B. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier prior to installation.

- C. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.
- D. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Times listed are for each MCC installed.
 - 2. Assist in location of devices, methods of mounting, field erection, etc.
 - a. 2 person-day
 - 3. Functional Completion testing.
 - a. 2 person-days
 - 4. Startup.
 - a. 2 person-days
 - 5. Commissioning.
 - a. 2 person-days
 - 6. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:
 - a. 2 person-days
 - 7. Person-day is defined as one 8-hour day, excluding travel time.
 - 8. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 - 9. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Provide in accordance with Section 01 66 10 “Delivery, Storage and Handling” and as specified.
- B. Shipping:
 - 1. Ship equipment, and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.
 - 2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
 - 3. MCCs shall be separated into shipping blocks no more than three vertical sections each. Each shipping block shall include a removable lifting angle, to allow attachment by suitable lifting equipment.
 - 4. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.
 - 5. Channel bases:
 - a. For front and rear, minimum of 1-1/2 inch by 3 inch (38 mm by 76 mm) standard channel with suitable holes for mounting motor control center, and holes for grouting and flow of concrete.
 - b. Shipped in advance with accurate template of motor control center mounting holes or dimension layout drawing for embedding in concrete pad, floor slab, or securing to floor.
 - 6. Attach lifting angles to main frame of structure to distribute weight equally. Deflection or distortion is cause for rejection.
 - 7. If the equipment cannot be placed into service after its receipt, store in a closed building or structure, in a clean, dry and ventilated area free from temperature, dirt and moisture extremes. Acceptable storage temperatures are from 0 degrees C (32 degrees F) to 40 degrees C (104 degrees F) with temporary heaters provided within enclosures to prevent condensation. Provide heavy plastic envelope directly over motor control center to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.
- C. Storage:
 - 1. Inspection and inventory items upon delivery to site.
 - 2. Store and safeguard equipment, material, and spare parts.

1.07 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 3. Indicating Lights: Two of each type and color installed.
 - 4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
 - 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.08 WARRANTY AND SERVICE

- A. Guarantee components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 12 months.
- B. Ensure that equipment manufacturer has local branch office staff with trained, full-time employees who are capable of performing testing, inspecting, repair, and maintenance services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. The equipment manufacturer shall be ISO 9001 or 9002 certified.
- B. Manufacturer's acceptable contingent upon products' compliance with the specifications.
 - 1. ABB.
 - 2. Siemens Energy & Automation, Inc.
 - 3. Schneider/Square D Company.
 - 4. Eaton.

2.02 COMPONENTS

- A. Motor control center construction: Comply with UL 845.

- B. Starters: Comply with the requirements of NEMA ICS 2.
- C. Instruments: Comply with ANSI C39.1.
- D. Enclosures:
 - 1. Enclosures for motor control centers: NEMA Type 1 gasketed, unless otherwise indicated on the Contract Drawings.
 - 2. Motor control centers: NEMA Class II-S, Type B wiring.
 - 3. Outline dimensions of motor control centers and arrange equipment and devices as indicated.
 - 4. The minimum depth of a motor control center is 20 inch (508 mm). Arrange motor control centers for back-to-back mounting of the starter units where indicated.
 - 5. Each MCC shall consist of one or more vertical sections of heavy gauge steel bolted together to form a rigid, free-standing assembly. A removable 7 gage structural steel lifting angle shall be mounted full width of the MCC shipping block at the top. Removable 7 gage bottom channel sills shall be mounted underneath front and rear of the vertical sections extending the full width of the shipping block. Vertical sections made of welded side-frame assembly formed from a minimum of 12 gage steel. Internal reinforcement structural parts shall be of 12 and 14 gage steel to provide a strong, rigid assembly. The entire assembly shall be constructed and packaged to withstand normal stresses included in transit and during installation.
- E. Buses:
 - 1. Locate main horizontal bus at top with ampere rating as indicated. Isolate bus from both front and back compartments.
 - 2. Neutral bus if required: Rated at full capacity.
 - 3. Main, vertical, and ground buses: 98 percent conductivity tinned copper bars of suitable size carried on supports fabricated from an acceptable insulating material.
 - 4. Short circuit bus bracing: As indicated.
 - 5. Vertical buses: A minimum rating of 300 amperes for front only units, a minimum rating of 600 ampere for back-to-back units. Insulate or isolate vertical buses.
 - 6. Provide continuous 2 inch by 1/4 inch (50 mm by 6 mm) tinned copper ground bus along length of the motor control center.
 - 7. Contact surfaces of bar-to-bar connections and lug-to-bar connections: Silver plated.
 - 8. Phase rotation of vertical buses: Make same when viewed from front or from either side of motor control center.

9. Bolts and other hardware: Galvanized or stainless steel or equal.
10. Provide horizontal wireways at top and bottom of each vertical section. Provide vertical wireways with wire supports for each vertical section. Interconnect all wireways.
11. Provide standard corrosion resistant fasteners for unit doors hardware which operate without special tools.

F. Barriers:

1. All power bussing and splice connections shall be isolated from the unit compartments and the wireways. The horizontal bus shall be mounted onto a glass filled polyester support assembly that braces the bus against the forces generated during a short circuit. The horizontal bus shall be isolated from the top horizontal wireway by a two-piece rigid non-conductive barrier. The barrier design shall allow qualified personnel to slide the barriers both left and right, to allow access to the bus and connections for maintenance without having to remove the barrier. Barrier sliding shall occur via an upper and lower track system.
2. The vertical bus shall be housed in a molded glass-filled polyester support that provides bus insulation and braces the bus against the forces generated during a short circuit. These supports shall have openings every 3 inch (75 mm) for unit stab-on connections. Each opening shall be provided with an automatic shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the MCC.
3. Barriers shall be provided in the vertical structure and unit designs to prevent the contact of any energized bus or terminal by a pull wire routed through the conduit or wireway areas.

G. Motor Control Center Units:

1. Motor control center units: Drawout type. Units larger than NEMA Size 4 having bolt-in construction. Provide fully interchangeable removable units of same size and type.
2. Interlock disconnect devices with associated doors, to prevent closing the disconnect device with the door open unless a tool is used or a defeater device is operated.
3. Furnish disconnect devices capable of being locked in either the open or closed position.
4. Arrange each unit so that when its starter has been removed, its door may be closed to cover the opening.

H. Motor Control Center Starter Units:

1. Unless otherwise indicated, use minimum NEMA Size 1 combination starter, consisting of a circuit breaker, or motor circuit protector and magnetic starter, as indicated. Momentary and interrupting ratings of circuit breakers, and motor circuit protectors coordinated with main bus bracing. Type of starters, i.e., full voltage, reduced voltage, reversing, non-reversing, two-speed, etc., are as indicated. Furnish magnetic starters with thermal overload protection on each phase with external manual reset.
2. Solid-State Overload Relay:
 - a. Provide a solid-state overload relay for protection of the motors.
 - b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
 - c. The overload relay shall be modular in design, be an integral part of family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
 - d. The overload relay shall have the following features:
 - (1) Self-powered.
 - (2) Class 10 or 20 fixed tripping characteristics.
 - (3) Manual or automatic reset.
 - (4) Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor.
 - (5) Visible trip indication.
 - (6) One normally open and one normally closed isolated auxiliary contact.
 - (7) Test button that operates the normally closed contact.
 - (8) Test trip function that trips both the normally and normally closed contacts.
 - (9) A current adjustment range of 3.2:1 or greater.
 - (10) Ambient temperature compensated.
 - (11) Ground fault protection. Relay shall trip at 50 percent of full load ampere setting.

- (12) Jam/Stall protection. Relay shall trip at 400 percent of full load ampere setting, after inrush.
3. Verify type (single- or 2-winding) of two-speed motor being installed. Furnish type of motor starter necessary for control of motor. Furnish decelerating, time-delay relay for each two-speed starter.
 4. Provide reduced voltage solid-state type starters (RVSS) with thyristor (SCR) bridge consisting of at least two SCRs per phase to control the starting and stopping of industry standard motors.
 - a. The soft start shall provide torque control for linear acceleration without external feedback independent of motor load or type of application.
 - b. The gating of the thyristors will be controlled in such a manner to ensure smooth and stable acceleration ramp.
 - c. The soft start shall be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCRs. Analog control algorithms shall not be allowed.
 - d. All soft start power ratings will utilize the same control board/module.
 - e. A shorting contactor shall be supplied with the soft start controller units. Protective features and deceleration control options integral to the soft start shall be available even when the shorting contactor is employed.
 - f. The soft start controller unit shall be designed to operate from an input voltage between minus 10 percent and plus 10 percent of nominal voltage rating.
 - g. The soft start controller unit shall operate from an input voltage frequency range of plus or minus 5 percent. By configuration, it shall be capable of operation at a supply line frequency that can vary by plus or minus 20 percent during steady state operation.
 - h. The soft start shall be capable of supplying 400 percent of rated full load current for 23 seconds at maximum ambient temperature.
 - i. All soft start controller unit power and control devices shall be rated heavy duty and capable of 5 evenly spaced starts per hour at 400 percent of full rated current for 25 seconds per start without tripping.
 5. Furnish starter operating coils suitable for operation on 120 volt, single-phase, 60 Hertz.
 6. Furnish each starter with at least one normally open and one normally closed auxiliary contact. Furnish additional normally open and/or normally closed auxiliary contacts for indicating lights, interlocking and other requirements as indicated.

7. Motor horsepower indicated on Contract Drawings may not be same as furnished, if larger motors are furnished, circuit breakers, fused switches, starters, wire and conduits of larger capacity may be necessary and, if so, furnish them at no additional cost.
 8. Furnish within each starter compartment a control transformer with primary fuses and secondary fuse. Secondary voltage 120 VAC, unless otherwise indicated. Determine load of each motor control circuit including equipment and devices provided under the other specification sections and furnish control circuit transformer 2-winding, dry-type of suitable volt-ampere rating, but not less than 75 volt-amperes. Control circuit loads may consist of but not be limited to solenoid operators, motorized valves, motorized dampers, relays, motor heaters, etc.
 9. Provide RVSS with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.
- I. Variable frequency drives (VFDs) shall be provided in MCCs where indicated. VFDs shall be in accordance with Section 26 29 23 "Variable Frequency Drives", and include 5 percent input reactors, and dV/dt output filters.
- J. Circuit Breakers:
1. Main, tie, and feeder breakers to be molded case circuit breaker with auxiliary contact for alarm on open or trip condition.
 2. Unless otherwise indicated, furnish manually operable circuit breakers and provide thermal-magnetic, inverse-time-limit overload, and instantaneous, short-circuit protection. U.L. listed circuit breakers conforming to NEMA Std. AB-1 and UL Std. 489.
 3. Breakers: Molded case type, rated 480 volts, 2 or 3 pole and having 100 ampere or larger frames. Minimum interrupting rating equal to bus bracing required. Furnish current limiting type, where indicated.
 4. Furnish overload protection on all poles with trip settings as indicated. Breakers of 225 ampere frames and larger with interchangeable trip units and adjustable magnetic trip elements.
 5. Furnish time-current characteristic curves and other necessary information and data for each size of breaker furnished.
 6. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

7. Circuit breakers shall have microprocessor-based rms sensing trip units as specified below:
 - a. All electronic trip molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.
 - b. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.
 - c. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:
 - (1) Adjustable long-delay pick-up setting with minimum of 10 settings
 - (2) Adjustable long-delay time - 0.5 to 24 seconds
 - (3) Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame
 - (4) Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping
 - (5) Adjustable instantaneous setting 2x to Max allowable by frame
 - (6) Where indicated, adjustable ground fault current pickup ($0.2 - 1.0 \times I_n$ in 0.10 x increments) and time (0.1 – 1.0 sec in 0.10 sec increments), with selectable flat or I2t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.
8. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of $\pm 2.0\%$ of the reading.
9. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.
 - a. Number of operations (load and no-load)
 - b. Number of trips (overload trips, short circuit trips)
 - c. Run time
 - d. Breaker ambient temperature.

- e. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.
 - f. All breaker health information shall be accessible via micro-USB port on front of trip unit and via embedded communications
10. Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.
- a. Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.
 - b. Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.
 - c. Waveform events shall capture and store all phase, neutral and ground currents.

K. Motor Circuit Protectors:

- 1. Motor circuit protectors being completely enclosed molded case devices with current sensing coil in each of 3 poles having adjustable magnetic trip setting by means of single knob on front. Motor circuit protector manually operable. Protector designed to meet NEC requirement concerning motor full load and locked-rotor current. Minimum interrupting rating equal to bus bracing required.
- 2. Where indicated, current limiters, completely enclosed in molded case, bolted to load end of motor circuit protector to provide at least 100,000 amperes symmetrical interrupting rating at 600 volts. Limiters coordinated with protector so at low level short circuit, protector interrupts circuit without limiter operation. Faults interrupted by limiter also trip the protector and open all 3 poles. Equip each limiter with an indicator to show that the limiter has interrupted a fault.

L. L. Contactors:

- 1. Contactors for electric heating and other non-motor loads: Similar to motor starters except without overload relays or heaters. NEMA size as indicated, except 30 amperes minimum rating, tungsten lampload.
- 2. Contactors for lighting loads: Mechanically held. Ampere ratings as indicated, except 30 amperes minimum rating tungsten lampload.

M. Control Devices:

- 1. Control relays: Heavy-duty, industrial or machine tool type with at least two normally open and two normally closed contacts. Coils 120 volts, 60 Hertz.

2. Contacts: Rated 10 amperes, 250 volt alternating current.
3. Time-delay relays: Adjustable, pneumatic type, range 2 to 60 seconds and operated on 120 volts, 60 Hertz, with at least one normally open and one normally closed timed contact.
4. Pushbuttons and instrument selector switches: Heavy-duty, oil tight units, 30 mm, rated 10 amperes continuous current at 120 volts.
5. Indicating lights: LED type, heavy-duty, oil-tight, 30 mm units with push-to-test features.
6. Control and selector switches: Rotary type with enclosed contacts. Equip each switch with rectangular escutcheon and pistol-grip handle, except handles for instrument phase selector switches equipped with round knurled or slotted handles. Switch contacts rated 10 amperes continuous, 600 volts.

N. Harmonic Equipment:

1. An active harmonic filter shall be provided to perform electronic cancellation of load produced harmonic currents such that the upstream power harmonic current and voltage shall be reduced below the IEEE 519 guidelines for load demand and voltage distortion limits. Performance of the filter shall be independent of the impedance of the power source, AC lines or back-up generator(s). Necessary current transducers, reactors, and operator interfaces shall be supplied with the MCC. A factory certified start-up technician shall be used to start up each harmonic filter to achieve optimum system performance.

O. Nameplates: Furnish each motor control center and each unit of motor control center with engraved nameplate. Nameplates of laminated sheet plastic, 1/16 inch (1.6 mm) thick, engraved to provide black letters on white background. Fasten nameplates in place with corrosion-resistant screws.

P. Instruments:

1. Instruments: Panel type, approximately 3-1/2 inch (89 mm) or 4-1/2 inch (114 mm) square as indicated, semi-flush mounted. Accurate within 1 percent of full scale. Select scales so full load readings occur at approximately 70 percent of full scale. U.L. listed instruments conforming to ANSI C39.1.
2. Furnish suitable instrument transformers. Conforming to ANSI C57.13.
 - a. Current transformers of window type and insulated for 600 volts.
 - b. Furnish potential transformers with current limiting primary fuses.
 - c. Current transformers for meters shall be metering accuracy.

- d. Terminate the secondary of all current transformers on shorting type terminal blocks before proceeding to any other device.
- 3. Running time meters: Mechanical style, panel-mounted, round, UL Certified, nonreset type, 3-1/2 inch (89 mm) with register to indicate hours and tenths of hours up to 99,999.9 hours. Meters to operate on 120 volts, 60 Hertz. Provide with 3-hole bezel mount.
- 4. Furnish current and potential test blocks with plugs where indicated. Clearly identify current, voltage and phase for blocks and plugs.

Q. Power Monitor:

- 1. Provide microprocessor-based monitoring device to provide local and remote monitoring of the electrical system.
 - a. Voltage input of 120 volts using voltage transformers.
 - b. Current input from current transformers, phase A, B, C and ground.
- 2. Comply with ANSI C12.16, Class 10.
- 3. Display data:
 - a. Current A, B, C, Average, Neutral, Ground.
 - b. Voltage - Phase to phase
 - (1) Phase to neutral
 - (2) Phase to ground
 - (3) Average values
 - c. Power - Watts
 - (1) Vars
 - (2) VA
 - (3) Phases A, B, C and System
 - d. Energy - KWH
 - (1) KVARH
 - e. Frequency
 - f. Demand - System current

- (1) KW
 - (2) KVAR
 - (3) KVA
- g. Power Factor - Phases A, B, C, System
- h. Percent THD Current - Phases A, B, C, N
- i. Percent THD Voltage:
 - (1) Phase to phase
 - (2) Phase to neutral
- j. Minimum and maximum values
- k. Monitor past events and thresholds.
- 4. Provide power monitor with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.

2.03 WIRING

- A. Conductors: Copper; size as required by load, except that no control wire is smaller than 14 AWG. Use insulation that is flame retardant, and moisture and heat resistant.
- B. Cables and conductors: Bundled and tie wrapped securely in wireways furnished.
- C. Identify internal wiring at terminations by T&B wire markers or equivalent.
- D. All spare starter auxiliary contacts to be wired to terminal blocks.
- E. Terminal Blocks:
 - 1. Rated 600 volt for power with current rating as required by loads.

2.04 MISCELLANEOUS DEVICES

- A. Kirk Key interlocks shall be provided as indicated on the drawings.

2.05 SPARE PARTS

- A. Furnish following spare parts for each motor control center:
 - 1. Twelve lamps for indicating lights.
 - 2. One coil for each size of starter furnished for each motor control center.

3. One complete set of fuses for each size furnished.
 4. One set of contacts for each size of starter furnished.
 5. One control transformer for each volt-ampere capacity unit furnished.
- B. Package items in suitable containers bearing labels clearly indicating contents and equipment with which used.

2.06 FINISH

- A. Finish motor control centers with ANSI No. 61, light-gray enamel over rust-resistant undercoat.
- B. Furnish instruments and control devices with standard black finish.
- C. Use, mixing, application, and curing of paint on items requiring painting in accordance with paint manufacturer's written recommendations.

2.07 FACTORY TESTS

- A. The entire MCC shall go through a quality inspection before shipment, verifying the equipment to the factory shop drawings. This inspection will include:
1. Physical inspection and verification of:
 - a. Structure including verification of all bolted connections,
 - b. Electrical conductors, including:
 - (1) Bussing including verification of all bolted connections.
 - (2) Wiring.
 - (3) Unit compartments.
 2. Electrical Tests:
 - a. Electrical tests include:
 - (1) Power circuit phasing.
 - (2) Control circuit wiring and verification of satisfactory operation of all relays and other devices.
 - (3) Instrument transformers.
 - (4) Meters.

- (5) Ground fault system.
 - (6) Device electrical operation.
 - b. AC dielectric tests shall be performed on the power circuit.
- 3. Markings/Labels, include:
 - a. Instructional and warning type labels.
 - b. Underwriters Laboratory (UL)
 - c. Inspector's stamps.
- 4. The manufacturer shall use integral quality control checks throughout the manufacturing process to ensure that the MCC meets operating specifications.
- B. Equipment that is shipped without evidence of the required tests being performed to verify satisfactory operation will be subject to non-acceptance.
- C. If the MCC cannot be placed into service reasonably soon after its receipt, store it in a clean, dry and ventilated building free from temperature extremes. Acceptable storage temperature is from 0 degrees C (32 degrees F) to 40 degrees C (104 degrees F).

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install steel channel sills that have suitable drilled holes for mounting, aligning, and bolting each motor control center in place. Method of mounting, as indicated. Size and arrangement of sills, as recommended by motor control center manufacturer and acceptable to Engineer. Paint completed sills with two coats of aluminum paint or other acceptable corrosion-resistant finish before being set in place. Properly set and level channel sills.
- B. If motor control center equipment pads are located on concrete floor slabs, furnish painted steel channel mounting sills and anchor bolts, in time for placing concrete for construction of concrete equipment pads.
- C. Install items in accordance with manufacturers' printed instructions.
- D. Verify all loads on the motor control center including equipment and devices provided under the other electrical and non-electrical specification sections. Provide information to motor control center manufacturer for sizing of buses, control transformers, and protective devices. Verify that cables and conduits for loads are sized for the actual equipment provide in accordance with the NEC.
- E. Set motor circuit protectors and circuit breakers based on load installed.

- F. Check and provide a thermal overload on each phase of a starter unit. Match overloads to motor being installed.
- G. Deliver spare parts to Owner.
- H. Provide conduit, wiring, and grounding interconnections.
- I. Perform continuity and operational tests on circuits to demonstrate that motor control center is operationally safe and functionally correct.
- J. Provide one set of manufacturer wiring diagrams marked with all changes made in the field.

3.02 TESTING

- A. Factory authorized technician shall witness all testing as required by Section 26 08 13 “Field Inspection and Acceptance Tests”.
- B. Adjust and verify all settings and inputs to meters and relays.

3.03 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.
- B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 27 17
CONTROL PANELS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This section describes materials and installation of custom control panels as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the "date of record" for the Work shall be considered the effective code or standard for the duration of the project.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
4. Refer to specific Division 26 Sections for additional referenced codes and standards.

B. Underwriters' Laboratories, Inc., (UL):

1. 486A: UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors
2. 508: Electrical Industrial Control Equipment.
3. 508A: Industrial Control Panels.
4. 1059: Safety Terminal Blocks.

- C. Electrical Safety Program, Electrical Equipment Safety Program, and Lockout/Tagout Program of Provo Public Works.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".

B. Submit a complete list of equipment, materials, and any details required to demonstrate that the equipment will function properly as a unit. This material shall include:

1. System configuration with single-line diagrams.
2. Detailed descriptions of equipment including weights, dimensions, installation requirements, and heat dissipations.
3. Internal panel layouts indicating spacing and dimensions.
4. Panel front layouts.
5. Comprehensive panel construction bill of materials.
6. Catalog cuts of devices used.
7. Control schematics, ladder diagrams, and interconnection drawings.
8. Nameplates.

1.04 MANUFACTURER'S SERVICES

A. Services of Manufacturer's Representative as stated in Section 01 43 00 "Quality Requirements" and as specified herein.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.
6. Control relays: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.01 DIAGRAMS

- A. Schematic diagrams shall show the equipment serial or tag number, the Owner's drawing number, contract number, or similar identification which will indicate the particular equipment to which the diagrams apply. Diagrams shall show all equipment in the electrical system including internal wiring of subassemblies. Diagrams of subassemblies may be furnished on separate sheets.
- B. Identify each device by a unique number or number-letter combination.
- C. Conductor Identification: Identify each conductor by a unique number, letter, or number-letter combination. Consecutive numbering is preferred. Conductors connected to the same terminal or tie point shall have the same identification. Where multiconductor cable is used, a color code may be used to supplement the above identification. Where color-coded multiconductor cable is used for wiring identical components, such as limit switches, the color code used shall be consistent and charted on related diagrams.
- D. Provide a schematic diagram for each electrical system. The schematic diagram shall be drawn between vertical lines that represent the source of control power. Show control devices between these lines. Show actuating coils of control devices on the right-hand side. Show contacts between the coils and the left vertical line.
 - 1. Where the internal wiring diagrams of subassemblies are furnished on separate sheets, they shall be shown as a rectangle in the schematic diagram with external points identified and cross-referenced to the separate sheets of the control circuit. Show coils and contacts internal to the subassemblies in the rectangle connected to their terminal points.
 - a. Exception No. 1: Where relay and electronic circuits are mixed, diagrams may be drawn between horizontal lines that represent the source of control power.
 - b. Exception No. 2: Overload relay contacts may be connected to the right of the coil (common) if the conductors between such contacts and the coils of the magnetic devices do not extend beyond the control enclosure.
 - 2. For clarity, show control device symbols in the order in which the controls are positioned on the diagram.
 - 3. Use a cross-referencing system in conjunction with each relay coil so that associated contacts may be readily located on the diagram. Where a relay contact appears on a sheet separate from the one on which the coil is shown, describe the purpose of the contact on the same sheet.

4. Show spare contacts.
 5. Show limit, pressure, float, flow, temperature sensitive, and similar switch symbols on the schematic diagram with utilities turned off (electric power, air, gas, oil, water, lubrication, etc.) and with the equipment at its normal starting position.
 6. Show contacts of multiple contact devices, e.g., selector switches, on the line of the schematic diagram where they are connected in a circuit. Indicate a mechanical connection between the multiple contacts by a dotted line or arrow. This does not apply to control relays, starters, or contactors.
 7. Additional charts or diagrams may be used to indicate the position of multiple contact devices such as drum, cam, and selector switches.
 8. Show the purpose or function of switches adjacent to the symbols.
 9. Show the purpose or function of controls such as relays, starters, contactors, solenoids, subassemblies, and timers on the diagram adjacent to their respective symbols. Show the number of positions of solenoid valves adjacent to the valve solenoid symbol.
 10. Show values of capacitors and resistors on the diagram.
 11. Descriptive terms for command and status functions shall be in the present or past tense. For example, Raise Transfer-Transfer Raised; Advance Transfer-Transfer Advanced. Do not use terms such as "Transfer Up."
- E. The panel front and internal layouts shall show the general physical arrangement of components on the control panel. Identify devices with the same marking as used on the schematic diagram. Spare panel space shall be dimensioned. The drawings shall include a layout of the operator's console or push-button station, but terminal numbers need not be shown.

2.02 CONTROL ENCLOSURES

- A. Design and test control enclosures in conformance with UL 508. Enclosure types shall be as follows unless noted otherwise in the drawings:

Indoor Use	NEMA Type 12 SST
Outdoor Use	NEMA Type 4X SST
Indoor or Outdoor Use, Corrosive Area	NEMA Type 4X SST

- B. The depth of the control enclosure or compartment shall be a minimum consistent with the maximum depth of the control devices plus the required electrical clearance. In no case shall the depth of the enclosure be less than 8 inches.

- C. Provide mounting panel for mounting of interior components. Panel finish shall be white enamel.
- D. Where heating from control devices results in a temperature rise which is detrimental to the contained equipment or its operation, provide louvers or forced air ventilation. Design ventilating openings to prevent the entrance of any deleterious substance. When forced air ventilation is required, the cabinets shall be pressurized. Air filters shall be of commercially available types and sizes.
- E. Where installed outside, provide panel with a sunshield cover to completely protect and enclose the control panel. Ensure the control panel HMI screen, where provided, is continuously shaded during operation such that the sunshield cover does not require removal to access the HMI.
- F. Provide a permanent metal data pocket attached to the inside of the enclosure. If space permits, the pocket shall be at least 10 1/2 inches (267 mm) wide and of depth and thickness to accommodate electrical diagrams.
- G. Enclosure construction shall be minimum 316 stainless steel. Finish shall be white enamel inside. Provide continuous hinges for enclosure doors with a single handle three-point latch system with padlocking provisions. Provide hasp and staples for padlocking.

2.03 CONTROL WIRING

- A. 120-volt control wiring shall be Type MTW, THWN, or THHN. Conductors shall not be smaller than No. 14 AWG. Ampacity shall be in accordance with the NEC.
- B. Instrumentation signal cables shall be of the type used for field wiring.

2.04 MARKING

- A. Identify wire terminations with a number to correspond with the schematic diagrams. Identification tags shall be preprinted white heat-shrinkable tubing, Raychem Thermofit TMS or equal.
- B. Plainly and permanently identify control and power devices using the same identification as shown on the schematic diagrams. Show identification for devices inside the enclosure on a plate adjacent to, not on, the device.
 - 1. Exception No. 1: Where the size or location of the devices make individual identification impractical, such as on electronic assemblies, use group identification.
 - 2. Exception No. 2: Where panel layouts do not permit mounting identification plates adjacent to components, such as relays, place the permanent relay identification on the relay where it is plainly visible, and provide a second identification on the top of the panel wireway cover directly below the relay. Identify the wireway covers to show their proper location.

C. Identification plates for devices mounted inside and outside the control enclosure shall be one of the following:

1. Laminated phenolic for engraving stock; white background with black lettering, a minimum of 0.062 inch (1.57 mm) thick. Hold plates in place with metallic drive screws or the equivalent. Use permanent adhesives for attaching nameplates to wireway covers.
2. Noncorrodible metal; a minimum of 0.031 inch (0.78 mm) thick for engraving stock or 0.012 inch (0.30 mm) thick for embossing stock. Hold plates in place with metallic drive screws.

2.05 SUPPLY CIRCUIT DISCONNECTING MEANS

A. Provide a supply circuit disconnect for each control panel. Disconnect shall be a circuit breaker mounted within the control enclosure operated by a variable depth flange-mounted circuit breaker operating mechanism.

2.06 PLC AND OIT EQUIPMENT

- A. Refer to Section 40 62 43 Programmable Logic Controllers.
- B. Each new PLC panel assembly is to include a constant voltage regulating transformer suitably sized for the panel load equal to Sola Hevi-Duty MCR series and incoming power transient surge suppression equal to Sola Hevi-Duty STV100K series. Connect the surge suppressor dry contacts to a PLC input at each panel and notify the control system integrator/programmer.

2.07 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. Control panels shall be equipped with a UPS for surge protection and battery backup of critical process control equipment. The UPS shall be panel mountable, and each control panel shall be appropriately sized to fit the unit. The UPS shall be a double-conversion system.
- B. Each UPS shall be sized for, and capable of, running the connected load for a minimum of 30 minutes. UPS shall be sized for 80% of rated load at maximum connected load.
- C. UPS Electrical Input Specifications
1. Nominal Voltage: 120VAC
 2. Voltage Range: 80-144VAC
 3. Input Power Factor: > 0.95
 4. Frequency: 60 Hertz +/- 3 Hertz.
- D. UPS Electrical Output Specifications

1. Voltage Regulation: +/- 3 percent of Nominal
2. Efficiency: > 85 percent
3. Frequency Regulation: +/- 3 Hertz on utility, +/- 1 Hertz on battery

E. UPS Communications Specifications:

1. A USB port shall be available for monitoring and configuring the UPS. An appropriate cable shall be supplied to connect to the UPS with a PC.
2. An Ethernet port shall be available with the ability to monitor the UPS utilizing the SNMP protocol.
3. A UPS Trouble normally closed contact shall be provided from the UPS and shall be connected to a PLC discrete input channel for notification and alarming.

F. UPS Battery Specifications:

1. All batteries shall be sealed, lead-acid batteries and shall be maintenance free. Batteries shall be hot-swappable. The UPS will indicate when the battery is weak and needs to be replaced.
2. The UPS shall be able to accept additional battery modules to extend the runtime of the UPS.

G. Acceptable Manufacturers:

1. Powerware 5 or 9 Series.
2. Liebert GTX Series.
3. APC Smart-UPS Series.

2.08 CONTROL DEVICES

- A. Provide 120-volt control circuit transformer if incoming power supply is not 120 volts. Provide minimum volt-ampere spare capacity that is in addition to the loads specified. Fuse one side of secondary winding and ground other side. Provide primary winding fuses on both lines.
- B. Provide indicator lights, selector switches, push buttons, meters, etc., as shown in the schematic diagrams, single-line diagrams, and as required for correct operation. Mount on the front panel of the control enclosure.
- C. Push buttons and selector switches shall be NEMA Type 4X. Provide with quantity of contact blocks required for correct operation. Units shall be UL listed with NEMA A600 rated contacts.

- D. Push buttons shall be standard size, round, flush head with momentary contacts.
- E. Selector switches shall be round with standard operator.
- F. Indicating lights shall be round, transformer type, NEMA Type 13, complete with color of lens indicated in drawings or as required and legend plate. Lamps shall be high-density LEDs. Indicating lights shall be push-to-test type.
- G. Control relays shall be magnetically held and shall have convertible contacts. Control relays shall be UL listed with NEMA A300 rated contacts and coil voltage, number of poles, and pole arrangement as indicated in the drawings. All relays shall be of the same manufacturer. Relays shall be Allen-Bradley Bulletin 700 or equal.
- H. Time delay relays shall be UL listed with contacts rated 10 ampere noninductive load, 120 volts, with coil voltage, number of poles, pole arrangement, and maximum timing adjustment as indicated in the drawings. Relays shall be plug-in, solid-state type with timing knob adjustment. Provide Potter Brumfield, Syracuse Electronics, ISSD, Allen-Bradley Type RT, or equal.
- I. Mechanically held relays shall have coil voltage, number of poles, and pole arrangement and rating as shown in the drawings. Provide integral coil clearing contacts.
- J. DC power supplies shall have ratings as required by the powered equipment. Provide integral overcurrent protection.

2.09 TERMINAL BLOCKS

- A. Provide terminal blocks for incoming and outgoing control wires. Wire and mount terminal blocks so that internal and external wiring do not cross over the terminals. Do not terminate more than two conductors at each terminal connection.
- B. Field wiring shall terminate on the "field side" of the terminal blocks. Do not connect internal panel wiring to the "field side" of the terminal blocks. Do not connect field wiring to the "panel side" of the terminal blocks.
- C. Terminal blocks shall be modular, rail mounted, rated at 20 amperes, 600 volts capable of terminating wire sizes No. 12 through No. 24 AWG and constructed of polyamide thermoplastic. Terminal blocks shall be UL listed in accordance with UL 486A and UL 1059. Current-carrying parts shall be copper or brass electroplated with tin/lead. Terminal connection shall be a screw clamp pressure plate connection, designed such that the clamping screw does not clamp the screw directly to the wire.
- D. Provide symmetrical steel assembly rails, end brackets, jumper bars, and other accessories as required for a complete terminal block assembly.
- E. Consecutively number terminal blocks from top to bottom with preprinted marking tags. Tags shall be white polyamide and hot printed with black symbols so that the print is permanent.

2.10 WIRING METHODS

- A. Panel wiring shall be neatly contained in panel wireways, including incoming and outgoing field control wiring. Panelways shall be white or light gray colored, restricted slot design, with matching snap-on covers. Provide panelways with mounting holes and nylon "push" rivets or machine screws for mounting. Panelways material shall be PVC or noryl.
- B. Provide minimum 2 inches (50 mm) of clearance between panelway and wire terminations to allow for clear viewing of wire identification marking.
- C. Tie wiring run to control devices on the front door together at short intervals and secure to the inside front door with adhesive mounts. Mounts shall be adjustable releasable-clamp type for wire bundles 0.69 inch (17 mm) in diameter or smaller or releasable nylon cable ties for bundles larger than 0.69 inch (17 mm) in diameter. Attach mounts to front panel with adhesive.

2.11 FACTORY TESTS

- A. Inspect and test control panel for correct operation. Test each circuit for continuity, short circuits, and fault grounds.

PART 3 - EXECUTION

3.01 FIELD TESTS

- A. Test control panel with field wiring connected. Set adjustable set points and time delays for proper operation of equipment. Check operation of control panel and field devices to verify correct operation. Perform required adjustments for correct operation.

3.02 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide field test, and place in operating condition, wiring devices as indicated and in compliance with Contract Documents.
- B. Provide exterior lighting control as indicated and in compliance with Contract Documents.

1.02 REFERENCES

- A. Federal Specifications (FS):
 - 1. W-C-596-F: Plug, Electrical Connector, Receptacle, Electrical.
 - 2. W-S-896-F: (1P-2P-3W) Switch, Toggle, Single Unit with wall plates.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. WD 1: General Requirements for Wiring Devices
 - 2. WD 6: Wiring Devices – Dimensional Requirements
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
- D. Underwriters' Laboratories, Inc. (UL):
 - 1. 20: General Use Snap Switches.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturer's product data in accordance with requirements of Section 26 05 10 "Electrical Work – General".

PART 2 - PRODUCTS

2.01 MANUFACTURER'S COMPLIANCE

- A. Manufacturer's acceptance contingent upon products compliance with specifications.
- B. Provide all devices with UL label.

2.02 MANUFACTURERS

- A. Allen-Bradley Co.
- B. Appleton Electric Co.
- C. Cooper Wiring Devices.
- D. Crouse-Hinds Co.
- E. Hubbell Electrical Products.
- F. Pass & Seymour, Legrand.
- G. OZ Gedney.
- H. Nelson Electric.
- I. Wattstopper.
- J. Greengate.

2.03 MATERIALS AND COMPONENTS

- A. Wall Switches:
 - 1. Provide alternating current, general-use, snap switches, in flush device boxes or on outlet box covers, totally enclosed in composition case, with insulated mounting yoke and sidewired, binding screw-type terminals. Single-pole, 2-pole, 3-way, or 4-way switches rated 20 amperes at 120/277 volts AC. Switch to meet Fed. Spec. W-S-896-F and UL-20.
 - 2. Switches for controlling lighting:
 - a. Cooper Wiring Device Cat. No. 2221, 222, 2223, or 2224.
 - b. Hubbell Cat. No. 1221, 1222, 1223 or 1224.
 - c. Bryant Electric Cat. No. 4901, 4902, 4903 or 4904.
 - d. Pass & Seymour, Cat. No. 20AC1, 20AC2, 20AC3 or 20AC4
 - 3. Provide pilot type lighting for switches controlling lights in seldom frequented locations.

B. Watertight Switches:

1. Provide watertight switches consisting of flush mounting switches in NEMA Type 4 gasketed cast metal boxes. Switch operable through shaft in matching cast metal cover, twenty-ampere, 120/277-volt switch enclosures:
 - a. Crouse-Hinds Type MC or MCC.
 - b. Appleton Cat. No. WDM 175 and WVG1.
 - c. OZ Gedney Cat. No. WSP and WCT120.

C. Occupancy Sensors:

1. Provide Occupancy Sensors as indicated on the plans. Provide power packs as need.
 - a. Low-Voltage Dual-Technology Ceiling Sensor: Wattstopper DT-305 or equal by Greengate.
 - b. Line-Voltage PIR Wall Sensor Switch, Wattstopper PW-301 or equal by Greengate.
 - c. Line-Voltage Dual-Technology Wall Sensor Dimmer, Wattstopper DW-311 or equal by Greengate.
 - d. Low-Voltage Dual-Technology Corner-Mount Sensor, Wattstopper DT-205 or equal by Greengate.

D. Flush Receptacles:

1. Provide 20-ampere, 125-volt flush receptacles constructed in flush device boxes, and of grounding type in composition case with insulated mounting yoke, side-wired, binding screw-type terminals. Receptacles to conform to Fed. Spec. W C 596-F.
2. Duplex receptacles:
 - a. Cooper Wiring Devices Cat. No. 5362.
 - b. Hubbell Cat. No. 5362.
 - c. Bryant Electric Cat. No. 5362.
 - d. Pass & Seymour Cat. No. 5342.
3. Duplex GFCI Type Receptacles:
 - a. Harvey Hubbell, Inc. Cat. No. CR5352.

- b. Cooper Wiring Devices Cat. No. GF20.
 - c. Leviton Manufacturing Company Cat. No. 6899.
4. Single receptacles:
- a. Cooper Wiring Devices Cat No. 5361.
 - b. Hubbell Cat. No. 5361.
 - c. Pass & Seymour Cat. No. 5351.

E. Special Receptacles:

- 1. Provide weatherproof while-in-use devices rated 20 ampere, 125-volt, consisting of duplex GFI receptacles with diecast powder coated aluminum, soft-gasketed hinged covers with stainless steel hardware. Covers as follows:
 - a. Hubbell Cat. No. WP26E.
 - b. Crouse-Hinds Cat. No. WIUMV-1X.
- 2. Provide in corrosive areas (NEMA 4X) a 20 ampere, 125-volt, consisting of duplex GFI receptacles with spring-loaded, soft-gasketed hinged covers with stainless steel spring. Device described above. Cover as follows:
 - a. Crouse-Hinds Cat. No. WLRS-1-S752.
- 3. Provide watertight, gasketed cast-metal enclosures with covers in areas subject to hose-down, meeting requirements, and either standard single or duplex type:
 - a. Appleton Electric Cat. No. AEE3382 and AEP3361, Style 2.
 - b. Crouse-Hinds Cat. No. ARRH33 and APJ3385, Style 2.
- 4. Provide receptacles with matching plug or cord cap designed to meet NEMA 4 requirements when plug, cord and receptacle are assembled.
- 5. Provide surface mounted “tombstone” style receptacles on laboratory island as shown on the plans. Provide die cast aluminum housing with minimum 3/4" conduit opening, two duplex GFI receptacles (one on each side) and stainless steel coverplates. For data outlets, provide the correct mounting for number of data connections shown.

F. Outlet Boxes and Enclosures:

- 1. Provide outlet boxes and enclosures conforming to Section 26 05 33 “Raceway and Boxes for Electrical Systems” and enclosure schedule on the drawings unless otherwise indicated.

G. Device Plates:

1. Provide device plates suitable for type of outlet boxes and enclosures used. Plates for flush-mounting by device manufacturer. Plates for surface-mounting boxes by either device manufacturer or box manufacturer.
2. Provide flush device plates of high corrosion resistant, Type 302 stainless steel.
3. Provide flush device plates of material and finish indicated, in certain designated areas.

H. Exterior Lighting Control Panel:

1. Provide Lighting Control Panel as indicated on the plans. Panel shall be UL listed and consist of the following:
 - a. Enclosure/Tub: NEMA 1.
 - b. Cover: Surface, hinged, lockable and shall restrict access to line voltage section.
 - c. Interior: Barrier for separation of high voltage (class 1) and low voltage (class 2) wiring. It shall include intelligence boards, power supply and control relays. Clock display and keypad shall be mounted on interior cabinet door for easy user access and programming.
2. Features:
 - a. Panel shall accept up to eight single pole relays. Relays shall be individual latching relays with 20 Amp load contacts for LED lighting loads. Provide isolated auxiliary contacts for pilot light switching. Relays shall use quick connectors and be individually replaceable to facilitate ease of use.
 - b. Panel shall provide a stagger up delay, override push buttons, pilot light outputs, and LED status light indicators for each relay or contactor control channel.
 - c. The clock shall have a backlight display, user keypad and shall provide 8 channels of time or astronomical control. Time clock shall provide up to 42 holidays, automatic daylight savings adjustment, astronomic coordinates by major cities, and help screens. Program memory shall be non-volatile and clock shall retain time keeping during power outages for at least 48 hours. Preprogrammed lighting control scenarios shall include:
 - (1) Scheduled On/Off
 - (2) Manual On/Scheduled Off

- (3) Manual On/Automatic Switch Sweep Off
 - (4) Astronomic Or Photocell On/Off and Astronomic or Photocell Control With Scheduled On/Off.
 - d. The panel shall have 8 universal switch inputs that are low voltage, self-configuring and shall not require programming to accept momentary on/momentary off switch, push button switch (cycling), maintained switch or 24VDC signals from occupancy sensors, photocells or other interfacing devices.
3. Manufacturer:
- a. Provide Wattstopper LP8S-8-115 Surface Mount with photocell EM-2-A2 or equal by Greengate.

PART 3 - EXECUTION

3.01 GENERAL

- A. Perform all work in accordance with the NEC.

3.02 CONNECTION

- A. Securely and rigidly attach wiring devices in accordance with regulating agency, and as indicated, avoiding interference with other equipment.
- B. Securely fasten nameplates using screws, bolts, or rivets and centered under or on the device, unless otherwise indicated.

3.03 GROUNDING

- A. Ground all devices in accordance with NEC.
- B. Ground switches and their metal plates through switch mounting yoke, outlet box, and raceway system.
- C. Ground flush receptacles and their metal plates through positive ground connection to outlet box and grounding system. Maintain ground to each receptacle by spring-loaded grounding contact to mounting screw, or by grounding jumper, both making positive connection to outlet box and grounding system at all times.
- D. Ground explosion proof receptacles and plugs by making contact between the metal shells, and also by using a grounding pin to make contact before power contacts are made.

3.04 LABELING

- A. All wall plates to be engraved with the panelboard alpha-numeric identifier and circuit breaker number.
 - 1. Characters to be 5/16 inch (8 mm) in size and black in color.
 - 2. All engravings to match panelboard typed circuit breaker directories.

3.05 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 29 23

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide complete simplex type Variable Frequency Drive (VFD) units and appurtenances including drive reactors, DC chokes, harmonic filters, enclosures, and certain auxiliary items, as indicated and as specified, to provide a complete operating system as indicated and in compliance with Contract Documents.
- B. If not installed in Motor Control Center, VFD units shall be furnished by the driven equipment manufacturer (pump, fan, etc.) supplier unless otherwise noted. Installation of the units shall be the responsibility of the General Contractor. All conduit and wire installations associated with each VFD shall be provided under Division 26.
- C. Provide individual stand-alone VFD units for the High Service Pumps as indicated on the plans and in this specification.
- D. VFD units shall be manufacturer's standard technology and in production for a minimum of 2 years.
- E. Provide control system operation, input and control signals, status signals and devices in accordance with Section 40 99 90 "Package Control Systems".
- F. Each VFD unit shall exhibit less than 3 percent voltage total harmonic distortion and less than 3 percent voltage distortion on each harmonic at their immediate upstream distribution bus as verified by calculation and testing. Harmonic current distortion to be in accordance with Table 26 29 23-1. This bus shall be referred to as the point of common coupling (PCC).
- G. Ratings shall be based on an altitude of approximately 4500'.

1.02 REFERENCES

- A. General:
 - 1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
 - 2. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the "date of record" for the Work shall be considered the effective code or standard for the duration of the project.

3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
 4. Refer to specific Division 26 Sections for additional referenced codes and standards.
- B. ASTM International (ASTM):
1. D178: Standard Specification for Rubber Insulating Matting
- C. National Electrical Manufacturers Association (NEMA):
1. ICS 2: Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.
 2. ICS 6: Enclosures for Industrial Controls and Systems.
 3. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 4. KS 1: Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 5. MG 1: Motors and Generators.
- D. National Fire Protection Association (NFPA):
1. 70: National Electrical Code (NEC).
- E. Underwriter's Laboratories Inc. (UL):
1. 198C: High-Intensity Capacity Fuses; Current-Limiting Types
 2. 489: Molded-Case Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 3. 508: Electrical Industrial Control Equipment.
 4. 1066: Low Voltage AC and DC Power Circuit Breakers Used in Enclosures.
- F. National Electrical Contractors Association (NECA)
1. NECA Standard of Installation
- G. Electrical Safety Program, Electrical Equipment Safety Program, and Lockout/Tagout Program of NTMWD.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions for all major components.
- C. Complete wiring and schematic diagrams for the equipment furnished. Each wiring diagram shall be legible and not reduced from the original design drafted format. Provide a list of equipment on each wiring diagram for which it is applicable.
- D. Panel layout and front view drawings.
- E. Time versus current curves for protection devices.
- F. Data sheets for all devices provided as part of the assembly.
- G. All other details required to demonstrate that system has been coordinated and will properly function as a unit.
- H. Provide enclosure drawings and details showing all dimensions and construction details.
- I. Submit information relative to location and expertise of local service office and personnel.
- J. Submit a Statement of Compliance indicating conformance to the Seismic Requirements specified. Certificate shall be signed and sealed by a Professional Structural Engineer holding current registration in the state for work of this project.
- K. For informational purposes only, submit manufacturer's printed installation instructions.
- L. Spare Parts Data: Submit a list of spare parts for the equipment specified.
- M. Operating and Maintenance Instruction Manuals:
 - 1. Furnish:
 - a. Operating instruction manuals outlining step-by-step procedures required for system startup and operation.
 - b. Manufacturer's name, model number, service manual parts list.
 - c. Brief description of equipment and basic operating features.
 - d. Maintenance instruction manuals outlining maintenance procedures.
 - e. Troubleshooting guide listing possible breakdown and repairs.
 - f. Point-to-point connection wiring diagram for the system.

- g. Performance Test Reports: Upon completion of installed system, submit in booklet form all shop and field tests performed to prove compliance with specified performance criteria.

N. Submit Pump, Motor and VFD Statement of Compliance Coordinate Certificate.

1.04 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.
- B. Provide VFDs in accordance with UL 508A, supplement SB, and Article 409 of the National Electrical Code (NEC). All VFD units shall be provided with a UL label.
- C. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.
- D. Review the proper installation of each type of VFD unit with the equipment supplier prior to installation.
- E. Services of Service Engineer, specifically trained on type of equipment specified. Person-day requirements listed exclusive of travel time. Times listed are per VFD not mounted in a Motor Control Center (MCC).
 - 1. Assist in location of devices, methods of mounting, field erection, etc.
 - a. 2 person-days
 - 2. Functional Completion Testing
 - a. 2 person-days
 - 3. Startup.
 - a. 2 person-days
 - 4. Commissioning.
 - a. 2 person-days
 - 5. At the end of start-up service provide for a maximum of six members of the owners staff at the facility site to receive training from the startup/testing service Engineer.
 - a. 1 person-day

6. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:
 - a. 2 person-days
7. Person-day is defined as one 8-hour day, excluding travel time.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Provide in accordance with Section 01 66 10 "Deliver, Storage and Handling" and as specified.
- B. Shipping:
 1. Ship equipment and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.
 2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
 3. Deliver spare parts after installation but as specified before start-up of drives. Deliver to Owner after completion of work.
- C. Storage:
 1. Inspect and inventory items upon delivery to site.
 2. Store and safeguard equipment, material and spare parts.
 - a. If the equipment cannot be placed into service after its receipt, store in a closed building or structure, in a clean, dry and ventilated area free from temperature, dirt and moisture extremes. Acceptable storage temperatures are from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C) with temporary heaters provided within enclosures to prevent condensation. Provide heavy plastic envelope directly over motor control center to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

1.06 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.07 WARRANTY AND SERVICE

- A. Guarantee components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 24 months after turning the equipment over to the Owner, and in this time period include onsite, parts and labor warranty. All labor to be performed by local factory trained service engineers.
- B. Ensure that equipment manufacturer has local branch office staff with trained, full-time employees who are capable of performing testing, inspecting, repair, and maintenance services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturer shall have at least five years commercial experience in the manufacture, operation and servicing of equipment of type, size, quality, performance, and reliability equal to that specified.
- B. Variable Frequency Drive Units:
 1. ABB Drives.
 2. Eaton.
 3. Schneider/Square D Company.
 4. Siemens Inc.

2.02 HARMONIC ANALYSIS

- A. Each VFD unit shall be designed such that there is less than 3 percent voltage total harmonic distortion at the PCC. Current distortion at the PCC will be in accordance with Table 26 29 23-1. For the purpose of the analysis, it will be assumed that the facility transformer feeding the electrical system is at a lightly (50 percent) loaded condition.

<p style="text-align: center;">Table 26 29 23-1 Maximum Harmonic Current Distortion in Percent II</p>
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Odd Harmonic						
Ratio	5 to 9	11 to 15	17 to 21	23 to 33	35 +	TDD
Less than 20	4.0	2.0	1.5	0.6	0.3	5.0
20 to 50	7.0	3.5	2.5	1.0	0.5	8.0
50 to 100	10.0	4.5	4.0	1.5	0.7	12.0
100 to 1000	12.0	5.5	5.0	2.0	1.0	15.0
1000 +	15.0	7.0	6.0	2.5	1.4	20.0
Notes: 1. Even harmonics are limited to 25 percent of odd harmonics. 2. DC offset distortions not allowed. 3. Ratio = I_{sc}/I_L where: I_{sc} = Maximum short circuit current at PCC. I_L = Maximum demand load current at PCC (fundamental frequency component)						

- B. For each VFD unit, provide a harmonic analysis study at the point of connection to the immediate upstream distribution bus (PCC), based on pre-submittal data.
1. Each VFD unit shall be designed such that there is less than 3 percent voltage total harmonic distortion and less than 3 percent voltage distortion on each harmonic at the PCC. Current distortion to be within the limits of Table 26 29 23-1. For the purpose of the analysis, it will be assumed that the electrical system is at a lightly loaded condition, 50 percent load. If the VFD loads exceed 50 percent system loading, assume system is loaded at VFD full load ratings.
 2. At each PCC, where more than one type or size VFD unit is to be connected, provide the following:
 - a. Contractor shall have the supplier of the largest drive (in Hp) provide a harmonic study for each point of common coupling based on pre-submittal information
 3. The Contractor shall supply the following pre-submittal information to the largest VFD supplier to complete the harmonics study.
 - a. Full load fundamental current for each VFD unit.
 - b. Harmonic currents on per unit basis of full load fundamental for each VFD unit.
 - c. Available fault current information from the electric utility and upstream transformer data.
 - d. Distribution transformer sizes and impedances, if any.

- e. VFD input line reactor and/or isolation transformer sizes and impedances from the utility source to the VFD units.
 - f. Conductor information between transformer secondary or generator terminals to the distribution buses and VFDs.
 - g. Generator kW, impedance, subtransient reactance generator constants for the condition when the electrical system is powered from the generator.
4. The results of the harmonics study shall verify that the levels of total harmonic voltage at each point of common coupling are less than 5 percent and that the voltage distortion on each harmonic is less than 3 percent. In addition, harmonic currents at the PCC will be within the limits of Table 26 29 23-1. The study shall separately consider each VFD distribution bus as points of common connection (PCCs). The study shall specify additional equipment required (e.g., filters) at each harmonic where harmonic reduction is required to ensure compliance.
- C. The study shall consider the following conditions:
- 1. The electrical system shall be powered by the electric utility, case 1, or solely by local generation, case 2.
 - 2. The study shall include an explanation of all assumptions, sources of data, methodologies and formulas used in the study and a summary of the study results.
 - 3. The Contractor shall supply all equipment required as a result of the final accepted harmonics study to comply with the requirements of Paragraph 1.01 F.

2.03 SYSTEM DESCRIPTION

- A. General Requirements for VFDs:
- 1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- B. Application: Constant torque and variable torque. Provide as required for the application.
- C. VFD Description: Variable Frequency Drive, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and adjustable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
- 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for

Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."

2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
 2. Input AC Voltage Unbalance: Not exceeding 3 percent.
 3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
 4. Minimum Efficiency: 96 percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
 6. Minimum Short-Circuit Current (Withstand) Rating: 22 kA, refer to plans for higher ratings as required.
 7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
 8. Humidity Rating: Less than 95 percent (noncondensing).
 9. Altitude Rating: Not exceeding 3300 feet (1000 m).
 10. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 11. Speed Regulation: Plus or minus 5 percent.
 12. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 13. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

- G. Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 40:1 speed range.
 - 1. Signal: Electrical.
- I. Internal Adjustability Capabilities:
 - 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3. Acceleration: 0.1 to 999.9 seconds.
 - 4. Deceleration: 0.1 to 999.9 seconds.
 - 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- J. Self-Protection and Reliability Features:
 - 1. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 - 2. Under- and overvoltage trips.
 - 3. Inverter overcurrent trips.
 - 4. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 - 5. Critical frequency rejection, with three selectable, adjustable deadbands.
 - 6. Instantaneous line-to-line and line-to-ground overcurrent trips.
 - 7. Loss-of-phase protection.
 - 8. Reverse-phase protection.
 - 9. Short-circuit protection.
 - 10. Motor-overtemperature fault.
- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

- L. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- O. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.
 - 1. Disconnect Rating: Not less than 115 percent of VFD input current rating.
 - 2. NO alarm contact that operates only when circuit breaker has tripped.
- P. To avoid damage of output IGBT components or slamming to motors, an E-stop operation shall trigger a freewheel stop on the drive before the main 3 phase contacts open from the E-stop.

2.04 PERFORMANCE REQUIREMENTS

- A. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.05 CONTROLS AND INDICATION

- A. Refer to control diagrams on plans for additional requirements.
- B. Status Lights: Door-mounted LED indicators displaying the following conditions, as a minimum:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.
- C. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.
- D. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- E. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
- F. Control Signal Interfaces:
1. Electric Input Signal Interface:
 - a. A minimum of two programmable analog inputs: 4-20mA dc.

- b. A minimum of six multifunction programmable digital inputs.
- G. Output Signal Interface: A minimum of two programmable analog output signal(s) 4-20mA dc, which can be configured for any of the following:
 - 1. Output frequency (Hz).
 - 2. Output current (load).
 - 3. DC-link voltage (V dc).
 - 4. Motor torque (percent).
 - 5. Motor speed (rpm).
 - 6. Set point frequency (Hz).
- H. Remote Indication Interface: A minimum of six programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - 1. Motor running.
 - 2. Set point speed reached.
 - 3. Fault and warning indication (overtemperature or overcurrent).
 - 4. PID high- or low-speed limits reached.
 - 5. Drive in remote.
- I. Provide an Ethernet port for network connection.
 - 1. VFD shall be capable of communicating via Modbus TCP/IP protocol.
 - 2. Network to allow a selection of standard and custom register values to communicate drive parameters, including:
 - a. Drive fault
 - b. Overload
 - c. Trip
 - d. Loss of control power
 - e. Speed
 - f. Power (kW)

- g. Amps (Phase A, B and C)
 - h. Voltage (Phase A-B, B-C, C-A)
3. Provide all components and drive programming to allow network interface with control system.

2.06 MOTOR PROTECTION RELAY

- A. For each High Service Pump VFD, provide a definite purpose microprocessor-based Motor Protective Relay (MPR) for protection, control and monitoring of the motors. The MPR shall meet UL 1053 standard.
- B. The true rms current into the motor shall be constantly monitored, and by means of a protective algorithm, separated into positive and negative sequence components. These components shall be used to determine the heating effects on the stator and rotor of the motor to provide maximum motor protection and utilization. The relay shall be capable of being connected by three-wire conductor or fiber optic to a remote Universal Resistance Temperature Detection Module (URTDM) located at the motor to monitor up to six motor winding, four bearing and one auxiliary RTD inputs or the relay shall be able to be direct connected to the RTD inputs. The MPR shall integrate the temperature input data from the URTDM with the protective algorithm. The protective curve algorithm shall be adaptive based on the motor temperature as measured by the URTD. The protective algorithm shall provide faster trip times for higher temperatures providing maximum motor protection and shall operate with a longer trip time for lower temperatures allowing maximum motor utilization. The MPR shall provide the following protective functions:
 - 1. Motor running time overcurrent protection (IEEE Device 49/51).
 - 2. Adjustable instantaneous overcurrent protection (IEEE Device 50) with adjustable start delay in one-cycle increments.
 - 3. Adjustable current unbalance protection (IEEE Device 46 -adjustable in percent unbalance).
 - 4. Rotor protection.
 - 5. Underload trip with start and run time delays (IEEE Device 37/2).
 - 6. Jam trip with start and run time delays.
 - 7. Auxiliary overtemperature protection with URTDM.
 - 8. Zero sequence ground fault protection (IEEE Device 50/51G) with adjustable start delay and run delay in one-cycle increments.
 - 9. Stator protection with URTDM (IEEE Device 49).

10. Motor bearing over temperature protection with URTDM (IEEE Device 38)
 11. Load bearing over temperature protection with URTDM (IEEE Device 38).
- C. Only the following settings shall be needed to define the motor thermal protection curve.
1. Motor full load amperes (FLA)
 2. Locked Rotor Current in percent of FLA
 3. Locked rotor stall time in seconds
 4. Ultimate trip current based on motor service factor.
- D. The following control functions shall be provided by internal solid-state based timers or relays:
1. Incomplete sequence delay (IEEE Device 2/19).
 2. Limitation on number of starts per time period in minutes (IEEE Device 66).
 3. Anti-backspin time delay (IEEE 2).
 4. Programmable transition relay based on current and/or time.
 5. Time between starts.
 6. Number of cold starts.
 7. Mechanical load shedding and restore function with timers.
 8. Zero speed switch input timer for use with long accelerating time motors.
- E. The MPR shall have a real-time clock for time tagging of events, operations and history. The relay shall have quick and easy access to monitored values, view settings, motor history and motor log records. The relay shall monitor and display the following:
1. Motor currents: Average current (Iave), individual phase and ground current in primary amperes and percent of full load and percent phase unbalance.
 2. Motor RTD: Individual winding, motor bearing, load bearing and auxiliary temperatures.
 3. Motor: Percent I²t (thermal accumulation), time until next start can occur, remaining number of starts, and time left on oldest start.
- F. The MPR shall be capable of accommodating external current transformers with ranges from 10/5 through 4000/5 amperes. Provide three current transformers sized per manufacturer's recommendations based on motor full-load amperes and service factor.

Where ground fault protection is specified, it shall be from an independent measuring circuit that utilizes either a separate zero sequence current transformer (50/51G) or residual scheme utilizing the three-phase current transformers (50/51N). For zero sequence ground fault protection, provide 50/5-ampere zero sequence transformer.

- G. Two user-programmable discrete inputs shall be provided for external control or trip functions. Programmable input functions shall be included for shutdown based on external contacts for incomplete sequence of operation and remote trip, remote reset, differential trip, motor stop, reset disable, zero speed switch or emergency override.
- H. The MPR shall be capable of providing a 4 to 20 mA output signal proportional to either the average of the three-phase currents, hottest winding RTD temperature or I₂t level.
- I. The unit shall draw its power from a control power transformer located in the starter.
- J. Provide separately mounted RTDM, mounted near the motor, to provide up to six stator RTDs, two motor bearing RTDs, and two load bearing RTDs and one auxiliary RTD.
- K. The device shall have separate Form C (NO/NC) Trip, two programmable Form C (NO/NC) Alarm and Auxiliary contacts. All contacts shall have ratings of 10-amperes at 115/240 Vac or 30 Vdc resistive. The alarm and auxiliary relay output contacts shall be programmable to operate from any internal protection function or from a discrete input signal such as differential trip or remote trip. All contacts shall be programmable to function in either a mode 1 (non-fail-safe) or mode 2 (fail-safe) operation. The device shall be capable of providing a 4 to 20 mA output signal proportional to one of the following user-selectable parameters:
 - 1. Average of the three-phase currents.
 - 2. Hottest winding RTD temperature
 - 3. I₂t level.
- L. The relay shall be capable of monitoring electrical current, receiving commands from remote sources either by contact closures or digital data, giving commands by means of contact closure to the motor starters and other devices under its control. The MPR shall be capable of displaying information by alphanumeric display to the operator or by digital communication signals to a remote location.
 - 1. The combination relay and operator panel shall be mounted on the door of the starter. Specific data entry to suit the actual motor application shall be programmed into the device by means of the operator panel pushbuttons
 - 2. Entered data shall be stored in non-volatile memory so as not to require battery backup. Non-volatile memory shall be capable of storing all setup information even after power failure, all monitored information at the time of a trip, and cause of trip even after power failure. Access to all programmed set points shall be restricted by means of a secured and sealed access cover.

3. Alphanumeric display shall read out (in English) complete description of all protective functions e.g., “instantaneous overcurrent” and all monitored and programmable data such as “percent of full load in amps” and “motor bearing temperature”.
 4. The MPR shall be user-selectable as to being programmable while the motor is running or require a motor shutdown for programming. If configured for programming while the motor is running, the protection shall stay active while programming is based on previous settings. Upon the user exiting the programming mode, the new settings shall take effect.
 5. The MPR shall have a user-selectable emergency override feature to reset I²t thermal accumulation and de-active start inhibit timers for emergency starting of the motor. The emergency override feature shall be capable of being activated from an access-restricted button, communications or via a contact input into the MPR.
 6. The MPR shall provide a programmable control function for reduced voltage applications for the transition from reduced to full voltage starting. The transition shall be programmable based on current, time current, and time.
- M. The MPR shall provide the following data logging and display capability for history including the date and time from when the history was last reset and counting began. The history shall include:
1. Resettable motor history for operational counter, run time, highest starting and running currents, highest percent phase unbalance, maximum winding, bearing and load RTD temperature, and number of emergency overrides.
 2. Re-settable Trip history for number of trips for ground faults, overloads, instantaneous overcurrent, JAM, underload, phase unbalance, RTDs, phase reversal, incomplete sequence, remote differential, communication, starts exceeded, time between starts, and transition.
 3. Re-settable Alarm history for number of alarms, for ground faults, overloads, JAM, underload, phase unbalance, RTDs, starts exceeded.
 4. A permanent history record which cannot be reset shall include total trips, run time and operations count.
 5. A log book including a chronological list of events or operations as detected by the MPR, such as, starts, stops, setting change, emergency override, trips, alarms or changes in the state of discrete inputs.
 6. An event log providing detailed information on trips and alarms including phase and ground currents, percent phase unbalance, maximum RTD temperatures, and cause of trip or alarm.

7. A start log providing information on the four most recent starts including maximum phase, and ground starting current, maximum percent unbalance, time from start to transition, current at transition, and time from start to run or trip.
- N. The MPR shall be provided in a quick release drawout case. The MPR shall have a user-programmable armed/disarmed feature with alarm indication. The disarmed mode shall permit relay installation while the motor is running with the trip outputs blocked. The draw-out case shall have a spare self-shorting contact to allow for continuous motor running or relay removed alarm functions.
- O. Provide a network communications card capable of changing set points, real time temperature for each RTD, transmitting all data, including trip/alarm data, a starting profile of the average phase current for the two most recent starts, all on MODBUS TCP/IP over Ethernet to the SCADA system.

2.07 LINE CONDITIONING AND FILTERING

- A. All VFDs shall include 3% effective impedance. If integral to the VFD, a DC choke shall be used. External line reactors must be used if no DC Choke is integral to the VFD.
- B. All VFDs shall include 5% effective line impedance. If integral to the VFD, a DC choke may be used in series with a 3% reactor. An external 5% impedance reactor must be used if no DC Choke is integral to the VFD.
- C. For VFD rated 480 volts, 50 horsepower and below 300 horsepower, supply an 18-pulse design using a multiple bridge rectifier with integral reactor and phase shifting transformer. The 18-pulse configuration shall result in a multiple pulse current waveform that approximates near sinusoidal input current waveform. The power section shall be insensitive to phase rotation of the AC line.
- D. For VFD rated 480 volts, 300 horsepower and up, supply with an Active Harmonic Filter (AHF). Provide a AHF in the same enclosure and sized for each VFD. The VFD and AHF shall come as a packaged unit with no additional cabling between units.

2.08 ENCLOSURES

- A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 1. Dry and Clean Indoor Locations: Type 1.
 2. Outdoor Locations: Type 4X.
 3. Other Wet or Damp Indoor Locations: Type 4X.
 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.09 SHOP TESTING

- A. Provide in accordance with Section 01 43 00.
- B. Provide a factory performance test for each variable frequency drive unit. The test to consist of simulating the expected load to be driven. The drive to operate the actual motor load through the expected speed ranges. Test length to be a minimum of two hours.
- C. Provide a factory burn-in test for 24 hours minimum and a control and alarm test on each drive unit by simulating each control signal and each alarm function to verify proper and correct drive unit action.
- D. Provide typical prototype factory test data for short circuit testing of each type of drive supplied. Data to verify that each drive can be started into a line-to-line fault and line-to-ground fault on the drive terminals. Each drive can be operating at full load and be subjected to a line-to-line fault and line-to-ground fault on the drive terminals. All phases (A, B & C) to be included in test data.
- E. Provide certified documentation of all tests performed.
- F. Provide above stated tests in addition to routine factory tests.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine VFD location for satisfactory preparation. Check conduits and raceway location for connection to units.
- B. Visually inspect delivered unit(s) and accessories for conformance with specification and drawings.
- C. Verify availability of appropriate pacing signal.
- D. Maintain variable frequency drive in upright position at all times.
- E. Protect adjustable frequency drive against damage. Store drive in clean, dry environment with temperature and humidity within range as specified by drive manufacturer. Energize space heaters during storage as recommended by manufacturer.

3.02 INSTALLATION

- A. Erect, install, and start-up equipment.
- B. The VFDs shall be installed as shown on the drawings, in accordance with the manufacturer's installation instructions, and accepted shop drawings.

- C. Install VFDs to allow complete door swing required for component removal. This is specifically required where a VFD is set in the corner of a room.
- D. Factory-trained service personnel, other than sales representatives, shall supervise field installation, inspect, make final adjustments and operational checks, make functional checks of spare parts, and prepare a final report for record purposes. Adjust control and instrument equipment until this equipment has been field tested.

3.03 RUBBER MATS

- A. For stand-alone units, three foot wide rubber mats shall be furnished and installed on the floor and in front of each VFD assembly. The mats shall be long enough to cover the full length of each VFD system. The mats shall be 1/2-inch (12 mm) thick with beveled edges, canvas back, solid type with corrugations running the long way, and shall be guaranteed extra quality, free from cracks, blow holes or other defects detrimental to their mechanical or electrical strength. The mats shall meet the requirements of ASTM D178 for Type II, Class 4 insulating matting.

3.04 FIELD TESTING

- A. Provide in accordance with Section 01 43 00 "Quality Requirements".
- B. Perform testing checkout, and start-up for VFD equipment under technical direction of manufacturer's service engineer. Under no circumstances energize any portion of the drive system without authorization from manufacturer's technical representative.
- C. Field Tests:
 - 1. Test each drive over the total speed range that it will be required to operate through for the load being driven for a minimum of two hours. Determine for each drive, motor, and load combination the following at minimum speed, maximum speed, and at 1/3 and 2/3 points between the minimum and maximum speeds:
 - a. Input power (kW), voltage, current and RMS power factor on the line side of the drive isolation device.
 - b. Output to the driven load in kilowatts.
 - c. For each drive, measure the harmonic voltage distortion and harmonic current distortion for each harmonic at the main distribution bus for maximum and minimum load conditions.
 - d. Measure the total harmonic voltage distortion and total harmonic current distortion at each PCC for maximum and minimum load conditions.
 - 2. Test each drive by using the actual control signal for remote and local operation.
 - 3. Test each drive's alarm functions.

4. Perform all tests in the presence of the Owner's representative.
5. Perform the above test in addition to the manufacturer's normal field tests.
6. Submit final test report with summary comparing field test data with harmonic analysis design calculated values for each drive.
7. Testing determined not in compliance with Contract documents shall be repeated by the Contractor at no additional cost to the Owner.

3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.
- B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.06 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 32 13

ENGINE GENERATORS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide and test ready for operation, three (3) natural gas engine-generator sets complete with appurtenances as indicated and in compliance with Contract Documents.
- B. The unit shall be provided in an outdoor, weatherproof, sound attenuated enclosure.
- C. The units shall have a 1000 kW (1250 kVA) power rating, standby, at .80 lagging power factor, three-phase, 60-Hertz, 480/277 volt, three-wire, four-wire alternating current generator. Rating shall be based on an altitude of approximately 4500'.
- D. The units shall be arranged for automatic starting and stopping, and load transfer upon failure of the normal source of power through automatic throw over system. The engine generator sets shall exhibit less than 20 percent voltage dip and less than 5 percent frequency dip during starting of the connected loads shown on the Contract Drawings one-line diagrams.
- E. The engine-generator package shall be complete in all respects and shall include all equipment and controls necessary for a fully operational standby power supply system.
- F. Provide galvanized steel platform and steps, with railing system at both sides of the engine generator sets to allow servicing the units from a raised platform.

1.02 REFERENCES

- A. Electrical Generating Systems Association (EGSA):
 - 1. 101P: Engine Driven Generator Sets.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 1: General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.
 - 2. 43: Recommended Practice for Insulation Testing of Large AC Rotating Machinery
 - 3. 112: Test Procedures for Polyphase Induction Motors and Generators.
 - 4. 120: Master Test Guide for Electrical Measurements in Power Circuits.

C. National Electrical Manufacturers Association (NEMA):

1. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
2. ICS 2: Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment.
3. ICS 6: Standard for Industrial Controls and System Enclosures.
4. MG 1: Standard for Motors and Generators.
5. PB 1: Standard for Panelboards.
6. SG 6: Standard for Power Switching Equipment.
7. MW36-C: Magnet wire.

D. National Fire Protection Association (NFPA):

1. 30: Flammable and Combustible Liquids Code.
2. 37: Installation and Use of Stationary Combustion Engines and Gas Turbines.
3. 70: National Electrical Code (NEC).
4. 110: Standard for Emergency and Standby Power Systems.

E. Society of Automotive Engineers International (SAE):

1. ARP892: DC Starter-Generator, Engine.
2. J537: Storage Batteries

F. Underwriters Laboratories (UL):

1. 142: Steel Aboveground Tanks for Flammable and Combustible Liquids.
2. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
3. 508A: Industrial Control Panels.
4. 1236: Standard for Safety Battery Charges for Charging Engine-Starter Batteries.
5. 1446: Systems of Insulations Materials.
6. 2200: Stationary Engine Generator Assemblies.

- G. Lateral Force Design Criteria as per applicable requirements for place of installation

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Submit shop drawings to show physical arrangements, connections, finishes, provisions for connections, access requirements for installation and maintenance, physical size, mechanical and electrical characteristics and ratings, foundation and support details, and equipment weights, where such details are not indicated on the catalogue cuts. The drawings and sketches shall be prepared in the latest version of AutoCAD. Within thirty (30) days after award, the vendor shall submit a complete set of shop drawings and product data. Provide specific data on the following:
 - 1. Outline drawings showing overall assembly and drawings illustrating arrangement (plan, front, and side views) and lifting provisions.
 - 2. Certified outline plan, general arrangement (setting plan), and anchor bolt details, including locations, sizes and model numbers of seismic isolators. Drawings shall show the total weight and center of gravity of the assembled engine-generator set on the structural steel sub-base.
 - 3. Arrangement detail of exhaust duct and muffler piping systems and the natural gas piping systems.
 - 4. Arrangement, size, and location of all electrical interface points and detailed elementary, schematic, wiring, and interconnection diagrams of the generator, exciter, governor, and other integral devices. Provide a wiring diagram including a complete schematic diagram.
 - 5. Dimensional drawings or catalog cuts of the exhaust silencer, oxidation catalyst, intake filter, pumps, starting equipment, battery chargers, batteries, battery racks, generator enclosure (if required) and dBA rating, and other auxiliary equipment.
 - 6. Arrangement or assembly drawings showing location of major auxiliary equipment in relation to the engine-generator set and details of fabricating all supports and connections thereto.
 - 7. Piping schematics for natural gas oil showing pipe sizes and valve locations.
 - 8. Engine-generator control panel.
 - 9. Specifications for a suitable fuel showing consumption performance using this fuel.
 - 10. Certified factory test.

- C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance.
 - 1. Failure to include a copy of the marked-up specification sections will result in return of the entire submittal without further review and consideration until the marked-up specification are resubmitted with the entire package.
- D. Outline equipment and enclosure drawings, equipment catalog cuts, wiring and connection diagrams and other documents required to completely describe the systems and equipment being furnished. Elevation drawings with shipping splits and estimated weights identified.
- E. Identification, description and dimensions.
- F. Engine-generator skid base drawings including spring vibration isolators. Drawings shall indicate size and location of anchor bolts, and conduit electrical device locations.
- G. Performance specifications of all items of equipment.
- H. Control panel layout drawings, dimensions, and component bill of materials. Outline drawings showing conduit entry areas and anchoring information. Description of control including operation of interface equipment.
- I. Complete electrical, instrumentation, control and wiring diagrams in sufficient detail to allow installation of instrumentation and controls and electrical components.
- J. Provide certificate of conformance to UL Standard 2200, Stationary Engine Generator Assemblies.
- K. Attenuation curve for the silencing equipment as offered to accomplish the required silencing for this installation.
- L. Information on the proposed jacket water treatment and procedures for flushing of the cooling systems.
- M. Operations and Maintenance Manuals, covering all equipment furnished, annotated to reference only the specific model numbers supplied. Include parts lists and parts prices current to the date of submittal; include information relevant to part supply and ordering. Submit prior to the startup and testing of the engine/generator units. Submit in accordance with Section 01 33 00 "Submittals", 01 78 23 "Operation and Maintenance Data" and as specified herein.
- N. Maintenance Manuals:
 - 1. Submittals shall include, but not be limited to, five (5) copies of the items listed below. Electronic files of all drawings and sketches using the latest version of AutoCAD. In addition, the vendor shall include any additional procedures judged necessary by the manufacturer to insure the maximum performance and service reliability for the engine-generator set.

2. The engine shop manual(s) including complete service instructions.
 3. Parts list with the manufacturer's or interchangeable part number.
 4. Drawings of the engine-generator set with center of gravity clearly indicated.
 5. Schematic and wiring diagrams of all power and control circuits for the engine-generator set and all its appliances and options.
 6. Fuel system piping diagram.
- O. Manufacturer's certified shop test record of complete engine driven generator unit.
- P. As-built drawings and material summary shall be shipped with the equipment.
- Q. Engine generator loading calculation, per the requirements of the connected loads shown on the one-line diagrams and other Contract Drawings.
- R. Data to be provided by engine generator system supplier:
1. Submit generator loading calculations and data for engine, generator, and accessories: (for rated kW capacity).
 - a. Engine Data:
 - (1) Manufacturer.
 - (2) Model.
 - (3) Number and arrangement of cylinders:
 - (a) RPM.
 - (b) Bore X stroke.
 - (c) Maximum power at rated RPM.
 - (d) BMEP at rated kW (including any parasitic loads and generator efficiency).
 - (e) Piston speed, feet per minute.
 - (f) Make and model of governor.
 - (g) Make and model of overspeed shutdown device.
 - b. Generator Data:
 - (1) Manufacturer.

- (2) Model.
- (3) Rated kVA.
- (4) Rated kW.
- (5) Voltage.
- (6) Temperature rise above 40 degrees C ambient. Stator by thermometer and field by resistance in degrees C.
- (7) Class of insulation.
- (8) Generator efficiency including excitation losses at 80 percent PF:
 - (a) Full load.
 - (b) Three quarters load.
 - (c) Half load.
- (9) Generator subtransient reactance in ohms and Per Unit value.
- c. Guaranteed maximum fuel consumption rate at generator terminals:
 - (1) Full load.
 - (2) Three-quarters load.
 - (3) Half load).
- d. Generator unit and accessories.
- e. Weight of complete unit, with break down by engine-generator set.
- f. Exhaust gas emissions data, maximum values at full load, 3/4 load, 1/2 load, and 1/4 load:
 - (1) Temperature in degrees F (degrees C).
 - (2) Flow in ACFM (mass and volume) (L/s).
- g. Combustion air requirement in CFM (L/s).
- h. Cold cranking amperes rating of engine starting batteries (CCA) at 0 degrees F (-18 degrees C).

- S. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.
- B. Contractor to ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Contractor to review the proper installation of the equipment and of each type of device with the equipment supplier prior to installation. The following service times are per generator.
 - 1. Services of Service Engineer, specifically trained on type of equipment specified. Person-day requirements listed exclusive of travel time.
 - a. Assist in location of devices, methods of mounting, field erection, etc.
 - (1) 1 person-day
 - b. Start-up and testing.
 - (1) 10 person-days
 - c. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:
 - (1) 2 person-days
 - d. Person-day is defined as one 8-hour day, excluding travel time.
- C. Anchorage of the system shall be designed to comply with the current applicable seismic source within 2 kilometers of the place of installation. The dead load assumed to resist overturning shall not exceed 0.75W.
- D. Manufacturer's Representative: Furnish the services of a qualified field engineer, experienced in the installation and operation of the type of systems being provided, to supervise the installation, testing, adjustment of the system, and to provide training for personnel.
- E. Manufacturer's Responsibility:
 - 1. The engine-generator set shall be manufactured by a single manufacturer who has been regularly engaged in the production of engine-generator sets for a minimum of 10 years. The emergency generator system described herein, including these components shall be factory built, factory-tested at rated load, starting duty and power factor, and shipped by this single manufacturer, so there is one source of supply and responsibility for guarantee, parts, and service. This manufacturer shall

- have a local representative in the Provo, UT Area who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.
2. The emergency generator system shall meet all requirements of NFPA 110, Level 2, including design specifications, prototype tests, one-step full load pickup, and installation acceptance.
 3. The responsibility for performance to this Section in its entirety shall not be split up among individual suppliers of components comprising the system but shall be assumed solely by the engine-generator set manufacturer. All controls shall be the standard of the engine-generator set manufacturer. Control parts shall be identified by parts numbers of this manufacturer and shall have second source listing where applicable. Control systems that are supplied by a vendor and not incorporated within the documentation drawings of the engine-generator set manufacturer are not acceptable.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Provide in accordance with Section 01 66 10 "Delivery, Storage and Handling" and as specified.
- B. Protect all equipment placed into storage from weather, humidity and temperature variations, dirt, dust, and other contaminants.

1.06 REGULATORY REQUIREMENTS

- A. Local State and City Air Pollution Control Laws.
- B. Provide all required data and information for a Title V local air pollution control district operating permit.
- C. Federal Clean Air Act (42 United States Code (U.S.C.) 7401 et. seq.)
- D. Federal Air Pollution Control Regulations: 40 Code of Federal Regulations (CFR) Parts 50-99, as amended by the Federal Register.
- E. Furnish to the Owner, within 15 working days of the date of any request, all documents and other information required to verify compliance with permit and applicable air pollution control laws and regulations, including EPA Tier 2 emission requirements in effect at the bid date of the project.

1.07 WARRANTY AND SERVICE

- A. Provide in accordance with Section 01 78 36.
- B. Guarantee all components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 24 months.

- C. Ensure that equipment manufacturer has local branch office staff with trained, full-time employees who are capable of performing testing, inspecting, repair, and maintenance services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Cummins Power Generation Inc.
- B. Caterpillar Inc.
- C. MTU.
- D. Kohler.

2.02 GENERAL

- A. Engine-generator set shall be a factory-assembled unit that is a standard production unit with existing torsional analysis data. Mixing and matching engine and generator by a third-party supplier is not acceptable. The engine and generator shall be directly connected with a flexible coupling, shall be free from injurious torsional or other vibration.
- B. The engine and generator shall be directly connected.
- C. The engine-generator set shall allow easy access to the various parts for maintenance purposes.
- D. The engine-generator set shall be pre-piped and pre-wired.
- E. The complete engine-generator unit shall be free from harmful torsional or other vibration throughout the entire operating range of speed and load. The engine manufacturer shall provide an analysis of the complete engine-generator unit, which shall show where any critical speed will be encountered, together with the order, the frequency and magnitude of any critical speed.
- F. The engine-generator set operating in an ambient temperature of 40 degrees C shall have a standby power capacity of not less than that indicated at 0.80 power factor, and shall operate at a speed not to exceed 1,800 rpm. It shall be rated 480/277 volt, as indicated, 3 phase, 4 wire, 60 Hertz.
- G. Frequency regulation shall not exceed 3 Hertz for step load from no load to rated load. Frequency variation shall not exceed plus or minus 0.3 Hertz for constant loads from no load to rated load.
- H. Voltage regulation for step load from no load to rated load shall be within +/- 4 percent of rated voltage for units up to and including 25 kW and within +/- 5 percent or percent of

rated voltage for units rated 30 kW or higher. Voltage variation shall be within +/- 1 percent of the mean value for constant loads from no load to rated load.

- I. The engine generator set shall be mounted on a heavy steel sub-base with spring type vibration isolators.

2.03 GENERATOR

- A. Generator shall be rated for continuous duty; shall be rotating field, engine-driven, direct-connected, synchronous type with amortisseur winding. Generator frame shall be dripproof with all openings guarded. Bearings shall be sleeve or sealed ball type. The generator shall be mechanically and torsionally matched to the engine driver and shall be provided to withstand inherent pulsating torques of the engine. Full load efficiency of the combined generator, exciter and regulator shall be not less than 95 percent. The generator windings, insulation and excitation system shall be braced to withstand any possible short-circuit stresses.
- B. Generator insulation shall be Class H or F in accordance with NEMA Standard MG1-1.65. Temperature rise shall be in accordance with NEMA Standard MG1-22.40 for continuous duty at all output ratings.
- C. Voltage regulator shall be an automatic, temperature compensated, solid-state type with a manual adjustment range of plus or minus 5 percent of rated voltage. The generator windings, insulation and excitation system shall be braced to withstand any possible short-circuit stresses.
- D. Exciter shall be PMG type. Minimum rating of exciter shall be as indicated in NEMA Std. MG-1-22.16.
- E. Components for field flashing and field discharge shall be included, if required. Fast acting fuses or other protective devices shall be incorporated where failure of regulator or exciter components could result in damage to the generator field or exciter windings.
- F. Voltage regulator and static exciter shall be mounted in generator control panel or elsewhere so as to protect from and isolate from vibration.
- G. The generator shall conform to the applicable parts of the following standards, unless otherwise specified:
 - 1. NEMA MG1, Motors and Generators.
 - 2. IEEE 43, Recommended Practice for Insulation Testing of Large AC Rotating Machinery.
 - 3. CSA C22.2- No. 100, Motors and Generators.
 - 4. Testing shall be in accordance with IEEE-115 and NEMA MG-1 standards

- H. The stator frame shall be fabricated bar and plate steel construction.
 - 1. All insulation materials used in the stator shall have a temperature rating of Class H per IEEE Standard 1. The coils shall be of a formed coil construction using a magnet wire meeting NEMA MW36-C specifications.
 - 2. The complete stator shall be wound with a 2/3 stator winding pitch and processed in a vacuum pressure impregnation chamber. Encapsulation of the stator shall be accomplished with a two-part epoxy system.
- I. Generator lead terminal box shall be of ample size to accept and terminate connecting cables as indicated on the drawings. Generator leads shall be furnished with terminal connectors suitable for the customers connecting cables.
- J. Provide generator stator winding heater with thermostat wired at 120 VAC to prevent formation of condensation.

2.04 ENGINE

- A. Heavy-duty compression-ignition, cold-starting natural gas type arranged for direct connection to an alternating current generator. It shall be a current model of a type in a regular production by a manufacturer regularly engaged in building this type of engine. Engine shall have at least a published intermittent brake horsepower rating at specified generator speed required by generator at rated full load output and shall operate without undue heating, vibration, or wear.
- B. Engine may be a two-cycle or four-cycle and may be naturally aspirated, scavenged, or turbocharged.

2.05 ENGINE ELECTRICAL SYSTEM

- A. Electrical system shall include a battery, starting motor, voltage and current-regulated charging generator or alternator, and a separate battery charger. Battery shall be of suitable capacity to start engine at conditions specified and shall be guaranteed for three years.
- B. Battery charger shall be automatic, two rate type providing for equalizing charge and continuous taper charging. Output characteristics shall match requirements of battery furnished. Provide charger suitable for operation on 120 volt, single-phase, 60 Hertz current to be rated not less than 10-amp direct current. Furnish battery charger with following features:
 - 1. Direct current voltage regulation: +/- 2 percent for variations in line voltage of +/- 10 percent.
 - 2. Direct current voltmeter and direct current ammeter, each with suitable scales.
 - 3. Automatic surge suppressor.
 - 4. Automatic current limiting to prevent overloading due to engine cranking, shorted output or reversed battery connections.
 - 5. Alternating current line fusing.

6. Equalize charge rate with manually set timer.
7. Integral protection to prevent battery discharge through charger on loss of alternating current line voltage.
8. Terminal block with terminals for all external connections.
9. Dry contacts to indicate charger failure.

C. Provide battery rack to accommodate starting batteries and supporting rack for battery charger. Rack shall be mounted in the enclosure.

D. Provide 120 VAC battery pad heater with thermostat.

2.06 ENGINE APPURTENANCES

A. Furnish engine with following appurtenances:

1. Combustion air cleaner of oil bath type or dry replaceable filter type. A tube shall connect crankcase breather with air cleaner to prevent accumulation of objectionable smoke and fumes.
2. Critical grade exhaust silencers complete with drains and flexible stainless-steel connection. The entire exhaust system shall be insulated.

B. Governors:

1. Provide electronic type governor capable of maintaining engine speed from no load to full load within 3 percent of synchronous speed.
2. Provide governors equipped with load sensing and load sharing controls.

2.07 CONTROL PANELS

A. Provide a fully solid-state, microprocessor based, generator control panel wired, tested and shock mounted on the generating set by the manufacturer of the generating plant.

B. Provide the following functionality integral to the control panel:

1. A minimum 64 x 240 pixel white backlight graphical display with text based alarm/event descriptions.
2. A minimum of 3-line data display.
3. Audible horn for alarm and shutdown with horn silence switch.
4. Standard ISO labeling
5. Multiple language capability
6. Remote start/stop control. Provide for multiple start/stop signals on separate inputs.
7. Local run/off/auto control integral to system microprocessor
8. Cool down timer
9. Speed adjust
10. Lamp test
11. Push button emergency stop button

12. Voltage adjust
13. Voltage regulator V/Hz slope – adjustable
14. Power Factor Control for paralleling units
15. Password protected system programming
16. Paralleling functions, including automatic and manual synchronizing, dead bus arbitration, load sharing, and load sense/load demand (LSLD).
17. Paralleling up to 16 generator sets (MGDL operation) or up to 8 generator sets (hard wired operation)
18. Automatic transfer/ Auto mains failure (AMF) functionality
19. Single generator to utility paralleling operation for temporary and extended utility paralleling operation.

C. Provide the panel with the following Digital indications:

1. AC voltage, 3-phase (L-L and L-N)
2. AC amps (3-phase and total)
3. KW (total and per phase)
4. KVA (total)
5. KVAR (total)
6. KWHR (total)
7. KVARHR (total)
8. PF (average total and 3-phase)
9. % of rated (total)
10. Frequency
11. DC voltage
12. System diagnostic
13. Excitation voltage
14. Excitation current
15. Engine oil pressure
16. Engine oil temperature
17. Engine coolant temperature
18. Engine RPM
19. Battery volts
20. Engine hours
21. Engine crank attempt counter
22. Engine successful start counter
23. Service maintenance interval
24. Real time clock
25. Oil filter differential pressure
26. Fuel temperature
27. Fuel pressure
28. Fuel filter differential pressure
29. Fuel consumption rate
30. Total fuel consumed
31. Engine intake manifold temperature
32. Engine intake manifold pressure
33. Engine crankcase pressure

34. Air filter differential pressure
 35. Boost pressure
 36. Oil filter differential pressure
- D. Provide alarm indication and subsequent shutdown for the following conditions (Store in the control panel the first and last occurrences of all alarms and shutdowns with a time, date, and engine hour stamp):
1. Low oil pressure alarm/shutdown
 2. High coolant temperature alarm/shutdown
 3. Loss of coolant shutdown
 4. Overspeed shutdown
 5. Overcrank shutdown
 6. High intake manifold temperature alarm/shutdown
 7. High exhaust manifold temperature alarm/shutdown
 8. High crankcase pressure alarm/shutdown
 9. High air inlet temperature alarm/shutdown
 10. Emergency stop depressed shutdown
 11. Low coolant temperature alarm
 12. Low battery voltage alarm
 13. High battery voltage alarm
 14. Control switch not in auto position alarm
 15. Battery charger failure alarm
 16. Generator over voltage
 17. Generator under voltage
 18. Generator over frequency
 19. Generator under frequency
 20. Generator reverse power
 21. Generator overcurrent
 22. Loss of excitation alarm/shutdown
 23. Instantaneous over excitation alarm/shutdown
 24. Time over excitation alarm/shutdown
 25. Rotating diode failure
 26. Loss of sensing
 27. Loss of PMG
- E. Provide accessible through a single electronic service tool all engine, voltage regulator, control panel and accessory units. Provide the following maintenance functionality:
1. Engine running hours display
 2. Service maintenance interval (running hours or calendar days)
 3. Engine crank attempt counter
 4. Engine successful starts counter
 5. 20 events are stored in control panel memory
 6. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

- a. Day of week
 - b. Time of day to start
 - c. Duration of cycle
 - F. Provide Ethernet port for communication with SCADA system via Modbus TCP/IP.
 - G. Parallel Engine Generators:
 - 1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
 - 2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
 - 3. Protective relays required for equipment and personnel safety.
 - 4. Paralleling suppressors to protect excitation systems.
 - 5. Reverse power protection.
 - 6. Loss of field protection.
- 2.08 CIRCUIT BREAKER
- A. Provide circuit breaker with solid-state adjustable instantaneous and short time delay features and ground-fault protection.
- 2.09 ENGINE COOLING SYSTEM (RADIATOR COOLED)
- A. Provide a unit-mounted radiator with integral jacket water circulating pump, and thermostatic control for cooling system.
 - B. Provide radiator of sufficient capacity to operate engine at full rated generator load at 120 degrees F (50 degrees C) ambient temperature.
 - C. Provide radiator with flange for connection to exhaust duct specified under Heating and Ventilating.
 - D. Provide engine coolant heater rated 208V, single phase, with thermostat.
 - E. Engine cooling system shall be charged with inhibited ethylene-glycol solution to provide antifreeze protection to -10 degrees F.
- 2.10 ENGINE LUBRICATION
- A. Provide full pressure system, supplying oil to all surfaces requiring lubrication. Circulation shall be by positive displacement pump. Full flow-type filters or filters with bypass feature shall be included. Filter elements shall be replaceable without disconnecting oil piping. Provide an oil cooler, if recommended by engine manufacturer, to properly lubricate engine at full rated generator load. Provide full charge of new oil after tests have been completed.

2.11 ENGINE GENERATOR SET ENCLOSURE

- A. Provide sound attenuated, weather-proof outdoor, walk-in type enclosure.
- B. Rigidity wind test equal to 120 mph.
- C. Roof load equal to 30 psf.
- D. Rain test equal to 5 inches per hour.
- E. Certified to meet following codes:
 - 1. IBC Code.
- F. Building to consist of roof, two side walls, and two end walls of pre-painted aluminum stressed-skin construction, door and door frame, lifting rings, mounting frame, insulation, electrical package, louvers, exhaust fan, muffler mounting bracket, and other appurtenances to make complete installation.
 - 1. Roof:
 - a. One piece combered roof sheet, min. 0.040 inch thick aluminum alloy, with extruded recessed side and end rails.
 - b. Roof bows, extruded "I" beams, spaced as required to carry loads.
 - 2. Walls:
 - a. Posts to be extruded aluminum sections, sized and spaced as required to carry loads.
 - b. Panels to be min. 0.045 inch thick aluminum sheet, mill-pre-painted, inside and outside, and riveted to posts.
 - 3. Door and Door Frame:
 - a. Provide welded aluminum door frame of extruded aluminum alloy, riveted to side panels.
 - b. Provide personnel door gasketed to form weathertight seal, panic bar hardware with three-point stainless steel locks and opening from inside in locked condition.
 - 4. Lifting Rings:
 - a. Provide four lifting rings, two in each side of roof, for lifting shelter only. Capacity of lifting rings to match load.

5. Mounting Frame:
 - a. Provide steel perimeter mounting frame for mounting onto concrete pad.
6. Insulation:
 - a. Provide semi-rigid fiberglass thermoacoustic insulation.
7. Sound Attenuation:
 - a. Provide sound attenuating features in the enclosure to maintain a maximum sound pressure level of 70 dBA at 7 meters with the generator operating at full load.
8. Electrical Package:
 - a. All equipment and devices UL listed. Provide 120/208V, 1-phase, 4-wire, with 60-amp main breaker. Provide eight (8) 20 amp branch circuit breakers. Panelboards shall conform to the latest NEMA standards, National Electrical Code and Underwriters Laboratories, Inc.
 - b. Circuits as follows:
 - (1) No. 1 - Lighting
 - (2) No. 2 - Receptacles
 - (3) No. 3 - Electric Heater
 - (4) No. 4 - Exhaust Fan
 - (5) No. 5 - Engine and Battery Heaters
 - (6) No. 6 - Battery Charger
 - (7) No. 7 - Motorized Dampers
 - (8) No. 8 - Spare
 - c. Electric heater, control stations, and thermostat shall be as recommended by the manufacturer, subject to review by the Engineer.
 - d. Receptacles shall be duplex, 20-amp, 125-volt, 3 pole, 2 wire and shall be a ground fault interrupter receptacle.
 - e. Light switch shall be toggle type, 15-amp, 120-volt, single pole.
 - f. Light fixtures shall be a ceiling or pendant mounted enclosed and gasketed vapor tight LED type with acrylic lens.
9. Manual Motor Starters:
 - a. Provide manual motor starters where indicated and for 120 volt, 60-Hertz fractional horsepower motors that do not have built-in thermal overload devices.

- b. Manual starters within sight of motors, as defined by NEC.

10. Louvers:

- a. Provide louvers and dampers for engine generator inlet and exhaust and ventilation air.
- b. Fixed louvers, all aluminum construction, riveted into aluminized steel frame to form rigid, water resistant assembly. Motorized dampers as specified hereinafter.
- c. Properly size louvers and dampers to allow sufficient engine combustion air, radiator cooling air, and ventilation air with maximum 0.5-inch water (125 Pa) restriction. Coordinate with engine generator manufacturer.

11. Muffler Mounting Bracket:

- a. Provide suitable bracket to secure critical grade generator silencer within the enclosure.
- b. Coordinate with engine generator supplier as required.

2.12 PAINT

- A. Paint for exterior surfaces of equipment shall be two coats of acceptable oil- and heat-resistant paint, applied after surfaces have been thoroughly cleaned and prepared with suitable priming coat.
- B. Provide touch-up paint in a quart container to Owner for use in field.

2.13 TOOLS

- A. Provide in accordance with Section 01 66 10.
- B. Provide all special tools required for maintenance and repair of unit in metal box complete with lock and keys.

2.14 FACTORY TESTING

- A. The complete engine-generator sets with enclosure shall be factory tested at full load using a 0.8 power factor reactive load bank to simulate a complete and integrated system prior to shipment.
- B. Provide all details of the proposed testing, including arrangements, test instruments and calibration, and procedures to be used to verify controls and alarms. The completed certified test record shall be submitted within 30 days after the completed test.
- C. Tests shall verify that unit will operate successfully and meet all specified operational requirements and verify adequate means of enclosure ventilation is provided.

- D. The factory test shall include four continuous hours of operation at full load and rated power factor. Voltage and frequency regulation and transient response shall be tested and recorded to show full compliance with this specification. During the factory test, readings shall be taken and recorded every thirty minutes for each of the following:
1. Time.
 2. Ambient temperature.
 3. Volts for each phase.
 4. Load:
 - a. Amps for each phase.
 - b. kW.
 - c. Power factor.
 - d. Frequency.
 5. Engine jacket water temperature.
 6. Lubricating oil pressure.
 7. Exhaust gas temperature.
 8. Fuel consumption.
 9. Noise Level measured 3 feet from source (dB)
- E. The procedure for the factory test of the engine shall include the engine manufacturer's standard practice.

PART 3 - EXECUTION

3.01 COORDINATION

- A. Coordinate with ventilation, fuel supply, and exhaust, to provide an efficient, well-coordinated layout.

3.02 INSTALLATION

- A. Install unit complete and make operational.
- B. Install muffler horizontally on spring type compensating hangers in generator enclosure.

- C. Provide 1/2-inch (12 mm) copper drain with draincock from bottom of muffler to nearest floor drain for periodic draining of muffler.
- D. Install engine at sufficient height above base to permit dropping oil pan without removing unit.
- E. Provide vibration isolation of exhaust equipment to prevent transfer of vibration into building components enclosing the standby power system.
- F. External conduit and wiring and transfer switch will be furnished and installed under applicable electrical sections, but all conduit, wiring and connections between the engine and its control panel and generator and its control panel, is included herein.
- G. Mount engine-generator set on a structural steel frame or skid. Provide vibration isolators suitable to prevent transmission of vibration to building structure between set and frame, and securely anchored to the concrete foundation. Obtain from supplier of engine-generator set a drawing giving location and size of foundation bolts for unit proposed, in sufficient time to be available when needed to place foundation. Galvanized anchor bolts shall be furnished by engine-generator set manufacturer.
- H. Electrical equipment and materials shall be listed by UL wherever standards have been established by that agency.

3.03 WIRING AND CONNECTIONS

- A. Provide conduit, wiring, and connections required and recommended by unit supplier. All conduit shall be terminated with flexible conduit. All wiring shall be multi-stranded.
- B. Connect neutral point of generator and generator frame to ground by green insulated copper conductor of adequate size.
- C. Connect motorized dampers in cooling and exhaust equipment to auxiliary contact on transfer controls to open dampers when unit is energized.

3.04 EQUIPMENT START-UP

- A. Operate the unit to demonstrate ability to operate continuously without vibration, jamming, leaking or overheating and to perform specified functions, after installation and after manufacturer's representative check of installed equipment.
- B. Comply with manufacturer's operating and maintenance instructions during start-up and operation.
- C. Make all final adjustments necessary to place the equipment in working order. Prior to any testing or operation of the units, the manufacturer's service representative shall inspect the installation, and shall certify, in writing, that the assemblies are, in all ways, ready for operation. Start-up shall not commence without the presence of the manufacturer's representative.

3.05 FIELD TEST

- A. Upon completion of the installation and as soon as conditions permit, the engine driven generator, including the engine, generator, electrical circuit controls, transfer controls other devices shall be tested in the presence of the Owner by the service representative for the manufacturer of the engine driven generator unit to verify that the system functions as specified.
 - 1. Perform load test with 0.8 power factor reactive load bank connected to the generator for a full load nameplate test. Run the test for a duration of four hours. Take system data readings each 20 minutes. Contractor to provide load bank for testing.
 - 2. The manufacturers' representatives shall make such changes in wiring or connections and such adjustments, repairs or replacements to make the circuit, device or control system function as specified and comply with the Contract Documents.
 - 3. Acceptance of test will be verified when the unit operates without alarm or abnormal conditions for the duration of the entire test. Retest if this requirement is not met until acceptance criteria has been verified.
- B. Record in 20-minute intervals during four-hour test:
 - 1. Kilowatts
 - 2. Amps
 - 3. Voltage
 - 4. Coolant temperature
 - 5. Air temperature
 - 6. Frequency
 - 7. Oil pressure
- C. As part of the field test, each of the automatic shutdown devices shall be tested and the respective values recorded at which the devices will stop engine. Any adjustments required shall be made in the devices to make the operating values correspond to those recommended by the engine manufacturer and as recorded during the stop test.

3.06 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 32 14

LOAD BANK

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This specification contains the minimum requirements for the design, manufacture and testing of outdoor weatherproof resistive load bank.

1.02 REFERENCES

- A. The equipment covered by this specification shall be designed with the latest applicable NFPA-70, NEMA, NEC, IEEE, and ANSI standards.
- B. The load bank certified to a Nationally Recognized Training Laboratory (NRTL) such as UL.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. The manufacturer shall submit for review technical data including features, performance, electrical characteristics, physical characteristics, ratings, accessories, and finishes.
- C. Shop drawings shall include dimensional plans and mounting details sufficient to properly install the load bank. Load bus configuration and load connections termination area shall be clearly identified.
- D. Electrical schematic drawings shall be provided to detail the operation of the load bank and the provided safety circuits. Over-current protection and control devices shall be identified and their ratings marked. An interconnection drawing shall be included for control wiring related to the load bank.
- E. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.
- B. Contractor to ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Contractor to review the proper installation of the equipment and of each type of device with the equipment supplier prior to installation.

C. Manufacturer's Representative: Furnish the services of a qualified field engineer, experienced in the installation and operation of the type of systems being provided, to supervise the installation, testing, adjustment of the system, and to provide training for NTMWD personnel.

1. Services of Service Engineer, specifically trained on type of equipment specified. Person-day requirements listed exclusive of travel time.

a. Assist in location of devices, methods of mounting, field erection, etc.

(1) 1 person-day

b. Start-up and testing.

(1) 2 person-days

c. Person-day is defined as one 8-hour day, excluding travel time.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 01 31 00 "Project Management and Coordination" and as specified.

B. Protect all equipment placed into storage from weather, humidity and temperature variations, dirt, dust, and other contaminants.

1.06 WARRANTY AND SERVICE

A. Provide in accordance with Section 01 31 00 "Project Management and Coordination".

B. Guarantee all components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 12 months.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ASCO.

B. Approved Equal.

2.02 GENERAL

A. The following specification is based on Model 3110 as manufactured by ASCO and is named to establish standards of quality. Equal products of other manufacturers conforming to these specifications may be provided as approved by the Engineer.

2.03 RATINGS

- A. The total capacity of the load bank system shall be rated at a minimum of 1000 kW 480 Volts, 3-Phase, 4-Wire, 60 Hertz, at 0.8 pf.
- B. The duty cycle shall be continuous, and the load bank shall operate in an ambient temperature of 40°C (102°F).
- C. Load steps are in minimum increments of 1 kW switchable to 100% of load.

2.04 ENCLOSURE CONSTRUCTION

- A. The load bank is packaged in an enclosure.
- B. The frame of the load bank is constructed from 2mm 'Zintec' steel, folded and welded to form a monocoque construction.
- C. Double skinned recessed doors allow easy access to the separate enclosures for control, switch gear and power connections.
- D. The double skinned, horizontal discharge duct with aluminised steel heat shield contains the resistive load elements and the cooling fan.
- E. Provide stainless-steel mesh screens on the main air inlet and outlet to provide protection against access to hazardous parts to IP1X.
- F. All electrical enclosures are to IP54.
- G. Provide a four-point lifting frame with corner tie bars to connect the frame to the fork base.
- H. High quality two-pack industrial acrylic paint system applied to an electro-plated zinc base and low-bake finish. Grey is color (RAL7042).

2.05 RESISTIVE ELEMENTS

- A. Provide with replaceable, non-finned sheathed elements. The outer sheath is made from stainless steel to give good corrosion resistance. The heating element shall be an 80/20 nickel-chrome wire embedded in compacted magnesium oxide powder, providing good thermal and insulation properties.
- B. The elements shall be conservatively rated and have no need for cooling fins to dissipate the heat into the airflow.
- C. The elements shall be designed to operate continuously at up to 800°C (red/orange). The operating temperature shall be below 500°C (dull red).
- D. Load tolerance shall be within 2-1/2% of total capacity.

- E. Elements shall be continuously rated at the specific voltage. Short-term tests with fluctuations up to 10% above rated voltage shall be permissible. Tests at lower voltages, with a corresponding reduction in overall rating, may be carried out. Power is proportional to voltage squared.

2.06 PROTECTION

- A. Provide with an emergency stop/disconnect switch with full isolation of the fan and control supply.
- B. A 110 Volt AC control circuit transformer provides isolation and operator safety.
- C. Provide with Stop/start buttons to ensure the load bank will not automatically restart.
- D. The fan motor shall be fully protected with fuses and a thermal overload.
- E. Each element group and its associated contactor shall be protected by an HRC fuse.
- F. The load contactors shall be interlocked with the fan controls to ensure load can be applied only when the fan is running.
- G. Internal access shall be restricted by key operated door catches. Polycarbonate screens behind the doors prevent accidental contact with live parts.

2.07 LOAD BANK CONTROL SYSTEM

- A. The system shall be controlled by a microprocessor-based module with non-volatile memory, specifically developed for load bank control and protection.
- B. All instrumentation measurements shall be made from high accuracy voltage and current transformers located within the load bank.
- C. To compensate for the voltage drop between supply and load bank, provision shall be made for remote voltage sensing via terminals.
- D. Load bank calibration and configuration shall be software controlled.
- E. The system shall have full three phase true RMS instrumentation.
- F. A load correction facility shall compensate for any voltage variation to ensure that the correct load is always applied.
- G. The system shall be capable of controlling up to 14 load banks including a mixture of resistive/ reactive units with proportional load sharing from one hand-held controller or a single PC.
- H. Control shall provide three phase instrumentation to class 0.5 accuracy.
- I. Control system shall provide 1kW load step resolution.

2.08 FACTORY TESTING

- A. The complete load bank with enclosure shall be factory tested at full load prior to shipment.
- B. Provide all details of the proposed testing, including arrangements, test instruments and calibration, and procedures to be used to verify controls and alarms. The completed certified test record shall be submitted within 30 days after the completed test.
- C. Tests shall verify that unit will operate successfully and meet all specified operational requirements and verify adequate means of enclosure ventilation is provided.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install unit complete and make operational.
- B. Securely anchor to the concrete foundation. Obtain from supplier of load bank a drawing giving location and size of foundation bolts for unit proposed, in sufficient time to be available when needed to place foundation.

3.02 WIRING AND CONNECTIONS

- A. Provide conduit, wiring, and connections required and recommended by unit supplier. All conduit shall be terminated with flexible conduit. All wiring shall be multi-stranded.

3.03 EQUIPMENT START-UP

- A. Operate the unit to demonstrate ability to operate continuously without vibration, jamming, leaking or overheating and to perform specified functions, after installation and after manufacturer's representative check of installed equipment.
- B. Comply with manufacturer's operating and maintenance instructions during start-up and operation.
- C. Make all final adjustments necessary to place the equipment in working order. Prior to any testing or operation of the units, the manufacturer's service representative shall inspect the installation, and shall certify, in writing, that the assemblies are, in all ways, ready for operation. Start-up shall not commence without the presence of the manufacturer's representative.

3.04 FIELD TEST

- A. The load bank shall be fully tested using a test specification written by the supplier. Tests shall include electrical functional testing, verifying conformance to assembly drawings and specifications.

3.05 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This section includes materials and installation of bypass-isolation automatic transfer switches with bypass as indicated and in compliance with Contract Documents.

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
- B. National Electrical Manufacturers Association (NEMA):
 - 1. ICS 2: Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.
- C. Underwriters Laboratories (UL):
 - 1. 1008: Automatic Transfer Switches.
- D. Lateral Force Design Criteria as per applicable requirements for place of installation.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Submit manufacturer's descriptive data including ratings, circuit diagrams, dimensional data, conduit entry restrictions, and a list of accessories.

1.04 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. Conform to the requirements specified in Section 01 41 20.
- C. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. Submit operation and maintenance manuals in accordance with Section 01 78 23 "Operations and Maintenance Data".

1.06 MANUFACTURER'S SERVICES

- A. Provide manufacturer's services at the jobsite for the minimum labor days listed below, travel time excluded:
 - 1. Two labor days to check the installation and advise during start-up, testing, and adjustment of the transfer switches.

PART 2 - PRODUCTS

2.01 TRANSFER SWITCH MANUFACTURERS

- A. The transfer switch shall be as manufactured by:
 - 1. Automatic Switch Company (ASCO).
 - 2. Russelectric Co.
 - 3. Zenith (ZTS).

2.02 TRANSFER SWITCH

- A. Transfer switch shall be as shown in the drawings. Transfer switch shall have number of poles, amperage, and voltage ratings as shown in the drawings. Withstand current rating shall not be less than 65,000 ampere rms symmetrical.
- B. Switch shall be listed per UL 1008 as a recognized component for emergency systems and be rated for all classes of loads.
- C. Automatic Open-Transition Transfer Switch: Interlocked to prevent the load from being closed on both sources at the same time.
 - 1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
- D. Operation shall be inherently double throw where normal and emergency contacts operate simultaneously with a momentary delay in a mid-position. An overload or short circuit shall not cause the switch to go to a neutral position. Do not use main contact structures not originally manufactured for transfer switch service (molded case circuit breakers or contactors). Inspection and replacement of all contacts (stationery and arcing) shall be possible from the front of the switch without any disassembly of operating linkages or power conductors. Provide a handle to permit no-load manual operation.

- E. Transfer switches with neutral controls shall have fully rated neutral transfer contacts that momentarily interconnect the neutrals of the two sources during the transfer/retransfer operations. The neutrals shall remain interconnected until the power source contacts close on the source to which the load is being transferred.
- F. The automatic transfer switch shall be mechanically held double-throw with a uni-directional drive mechanism. The transfer action shall be completely electrical and shall not rely on springs or counterweights. Operating coils shall be momentarily energized from the source to which the load is being transferred. The switch shall be interlocked electrically and mechanically to prevent simultaneous feeding of the load from both normal and emergency power sources. The transfer switch shall not have an intermediate position. A handle shall be provided to operate the transfer switch mechanism manually in case of automatic drive mechanism failure.
- G. Transfer switch shall be draw-out type with automatic secondary disconnects remove control power as switch is withdrawn and automatic shutters isolate bus when the transfer switch is withdrawn.
- H. Bypass-Isolation Switch Features
 - 1. Bypass switch and transfer switch have identical electrical ratings.
 - 2. Mechanical interlocks prevent unintended operation.
 - 3. Bypass contacts carry current only during bypass operation.
 - 4. Draw-out design eases transfer switch maintenance.
 - 5. The bypass switch has dead-front quick-make, quick-break operation for transferring loads between live sources.
 - 6. Bypass switch is rated for use as a 3-position manual transfer switch.
 - 7. Bypass-Isolation Handles are permanently mounted
 - 8. Mechanical indicators show bypass and transfer switch positions.

2.03 ACCESSORIES

- A. Provide a solid-state sensing and control logic panel. Include the following operational characteristics:
 - 1. Adjustable (0.5 to 6.0 seconds) time delay on engine starting to override momentary dips in normal source, set at 1 second.
 - 2. Full phase voltage relay supervision of the normal source with at least one close differential relay to detect "brownout" condition, set at 70 percent dropout and 90 percent pickup.

3. Voltage/frequency lockout relay to prevent premature transfer, set at 90 percent voltage and 90 percent frequency.
 4. Engine starting control contacts. Provide for multiple start control contacts. Provide a minimum of two normally open and two normally closed.
 5. Adjustable (2 to 25 minutes) time delay on retransfer to normal, set at 20 minutes.
 6. Unloaded running time delay for generator cool down (adjustable 0.1 to 10 minutes), set at 5 minutes.
 7. Transfer to emergency time delay (adjustable 1 to 300 seconds), set at 1 second.
- B. Provide a system test switch (momentary type) on the front of the enclosure.
 - C. Manual push button to bypass the time delay on retransfer.
 - D. Indicating lights to indicate source to which the load is connected.
 - E. Indicating light to indicate presence of normal power source.
 - F. Auxiliary contacts for remote indication of switch position, one normally open and one normally closed contact for normal and emergency position. Auxiliary contacts for remote indication of switch failure.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Secure transfer switch rigidly to wall and floor or mounting pad with anchor bolts or Phillips Drill Company concrete anchors. Anchor bolts or concrete anchors shall be Type 316 stainless steel.

3.02 FIELD TESTING

- A. Field test per manufacturer's recommended standard test procedure.
- B. Field test and calibrate timing and monitoring logic. All adjustments shall be within 5 percent of the previously specified set points.
- C. The transfer switch shall be tested under full load rating with external load in accordance with Codes and Standards as specified. The Subcontractor shall be responsible for providing test equipment required for testing under full load rated condition.
- D. The transfer switch shall be full load tested. Controls shall be tested under modes of operations.
- E. The switch testing shall be performed by the Subcontractor.

- F. The Subcontractor shall be responsible for correcting any deficiency found during testing of the unit at no cost to the owner.
- G. The Subcontractor shall provide the owner the factory certified test report within five (5) days of the completion of testing.

3.03 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide lightning protection system on each building and structure consisting of air terminals, conductors, ground terminals, interconnection conductors, arresters, and other connectors or fittings required for a complete system as indicated and in compliance with Contract Documents.
- B. All systems are to be designed, furnished and installed by a Lightning Protection Contractor.

1.02 REFERENCES

- A. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE):
 - 1. 837: Standard for Qualifying Permanent Connections Used in Substation Grounding.
 - 2. 70: National Electrical Code (NEC).
 - 3. 780: Lightning Protection Code.
- B. Underwriters' Laboratories, Inc. (UL):
 - 1. 96: Lightning Protection Components.
 - 2. 96A: Installation Requirements for Lightning Protection Systems.

1.03 SUBMITTALS

- A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Shop Drawings:
 - 1. Consisting of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, installation instructions.
 - 2. Shop drawings indicating type, placement, and location of protection devices, including cable attachments, grounding, mounting and any other details integral with the system.

- C. Spare Parts Data: Provide a list of recommended spare parts for the material and equipment to be provided, including current unit prices and source of supply (indicate which supplies are furnished at no extra cost with purchase of equipment).
- D. Inspection and Maintenance: Provide a written recommended inspection and maintenance procedure, including periodicity of inspections.
- E. Record Drawings: Provide a complete set of "as-constructed" drawings showing the location of all grounds as well as a detailed layout of type, size, location and method of installation of all downleads, roof cables, bonding leads and connections, air terminals, etc., and in the case where structural steel is used for downleads, the method and location of all roof and ground connections to the steel must be clearly detailed.

1.04 QUALITY ASSURANCE

- A. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied.
- B. Services of Manufacturer's Representative as stated in Section 01 43 00 "Quality Requirements" and as specified herein.
- C. Provide systems designed, furnished and installed by a Lightning Protection Contractor.
- D. Provide a "Certificate of Compliance" for work performed after completion. The certificate should state that the following has been done:
 - 1. The Contractor has complied with all requirements of Underwriters' Laboratories, Inc. Master Label Service as outlined in UL 96A including the completion and execution of the Master Label application form and the procurement and delivery of the U/L "C" plate to the Owner or his representative.
 - 2. The lightning protection system ground system has been tested and interconnected to the facility grounding system as required by NFPA 70.
 - 3. Record drawings have been turned over to the Owner or his representative.
- E. Use UL listed components.

1.05 REQUIREMENTS OF REGULATORY AGENCIES

- A. Conform to UL 96 and 96A and NFPA 780.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10 "Delivery, Storage and Handling".

B. Shipping:

1. Ship equipment and materials, complete with identification and quantity of items.
2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
3. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.

C. Storage:

1. Inspection and inventory items upon delivery to site.
2. Store and safeguard equipment, material and spare parts.

1.07 WARRANTY AND SERVICE

- A. Guarantee components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 12 months.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Thompson Lightning Protection Company, St. Paul, MN.
- B. Heary Brothers Lightning Protection Company, Springville, NY.
- C. American Lightning Rod Co., Dover, NH.

2.02 MATERIALS

- A. Class I Materials: Provide conductors, fittings, and fixtures necessary to protect ordinary buildings and structures not exceeding 75 feet (23 m) in height.
- B. Materials, Class I. Table I gives minimum sizes and weights for air terminals, and main and secondary conductors. Secondary conductors which are used for bonding and interconnecting metallic bodies to the main conductor, and which will not be required to carry the main lightning current, may be reduced in size but not less than No. 6 AWG copper or equivalent. Provide main conductor size for interconnection to metal water systems, steam or hot water heating systems, or other metallic masses having a low resistance to ground.

C. Table I: Class I Material Requirements.

Type of Copper Conductor		Standard	Metric
Air Terminal, Solid	Min. Diameter	3/8-inch	9.5 mm
Air Terminal, Tubular	Min. Diameter Min. Wall Thickness	0.032 inch	15.9 mm 0.8 mm
Main Conductor, Cable	Min. Size ea. Strand Wgt. per Length Cross Sect. Area	17 AWG 187 lbs/1000 ft. 57,400 cm	278 g/m 29 square mm
Main Conductor, Solid Strip	Thickness Width	16 AWG 1 inch	25.4 mm
Secondary Conductor Cable	Wire Size Number of Wires	17 AWG 14	14
Secondary Conductor Solid Strip	Thickness Width	16 AWG 1/2 inch	12.7 mm

D. Class II Materials: Provide conductors, fittings and fixtures necessary to protect ordinary buildings and structures exceeding 75 feet (23 m) in height; or one of any height which has a structural steel frame that may be substituted for lightning down conductors. Table II give minimum sizes and weights for air terminals and secondary conductors for Class II structures.

E. Table II: Class II Material Requirements.

Type of Copper Conductor		Standard	Metric
Air Terminal, Solid	Min. Diameter	1/2-inch	12.7 mm
Main Conductor, Cable	Min. Size ea. Strand Wgt. per Length Cross Sect. Area	16 AWG 375 lbs/1000 ft. 115,000 cm	558 g/m 58 square mm
Secondary Conductor Cable	Wire Size Number of Wires	17 AWG 14	14
Secondary Conductor Solid Strip	Thickness Width	16 AWG 1/2-inch	12.7 mm

F. Where any part of a protection system is exposed to mechanical injury, provide protection by covering it with molding or tubing. If ferrous metal pipe or tubing is used around the conductor, connect the conductor electrically to the pipe or tubing at both ends.

G. Furnish conductors made of stranded copper.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Provide all material, equipment, and labor to install the lightning protection system as indicated and as specified.
- B. No bend of conductor is to form an included angle of less than 90 degrees nor have a radius of bend less than 8 inches (203 mm).
- C. Interconnect all conductors, air terminals to form a two-way path from each air terminal horizontally or downward to connections with ground terminals.
- D. Conductors may be coursed through air without support for a distance of 3 feet (900 mm) or less. With a 5/8-inch (15.9 mm) rod or its equivalent as a support, securely fastened at each end, a conductor may be coursed through air for a distance not to exceed 6 feet (1800 mm).
- E. Install roof conductors to interconnect all air terminals and provide a two-way path to ground horizontally or downward from the base of each terminal.
- F. Install at least two down conductors on any kind of structure. Location depends on placement of air terminals, size of structure, most direct coursing, security against displacement and location of metallic bodies, water pipes, and ground conditions. Separate down conductors as widely as practicable. For structures over 200 feet (60 m) in perimeter, install one additional down conductor for each additional 100 feet (30 m) of perimeter or fraction thereof.
- G. Terminate each down conductor at a ground terminal.
- H. Bond radio and television masts of metal, located on a protected building, to the lightning protection system with a main-size conductor and fittings.
- I. Use connector fittings on all lightning conductors at "end-to-end" "tee" or "Y" splices. Attach them so as to withstand a pull test of 200 pounds (890 N). Make fittings for connection to metal tracts, gutters, downspouts, ventilators, chimney extensions, or other metal parts about the structure tight to the object by compression under bolt heads. Both crimp type and exothermic weld splicers of stamped or cast metal are acceptable under Class I requirements. Do not use crimp type clamps and splicers in Class II installations.
- J. Securely attach conductors to the building or other object upon which they are placed. Use fasteners not subject to breakage. Furnish nails, screws and bolts, with which fasteners are secured, of the same material as the conductor or of such nature that there will be no electrolytic corrosion in the presence of moisture because of contact between the different parts. Space conductor fasteners not more than 3 feet (900 mm) apart on all conductors.

- K. All requirements covering exposed systems apply to concealed installations. Conductors are coursed the same except that they may be coursed behind the exterior wall facing, in concealed or embedded conduit, or embedded directly in concrete.
- L. L. In a concealed installation where conductors are embedded in concrete, bond the reinforcing steel to the cable with a main size conductor. Bond reinforcing steel at the top and bottom of each embedded downlead.
- M. Materials, installation methods and procedures are to be in accordance with UL 96 and 96A, NFPA 780, NEC, and local electrical codes. Provide for and obtain a "Certificate of Compliance" for the work performed.

3.02 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 43 00

SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide Surge Protection Devices (SPD) components either integral to or in combination with the electrical distribution system equipment as indicated and in compliance with Contract Documents. The distribution system includes switchboards, motor control centers, 480V distribution panels and 120V panelboards.
- B. The components shall provide protection for electrical and electronic devices against the damaging effects of surges, transients and electrical line noise.
- C. Where indicated on the electrical contract drawings, provide separate, modular components from the electrical distribution equipment enclosures. Provide conduit, cable and all associated components for a complete SPD system installation. It shall be the Electrical Contractor's responsibility to verify adequate space for locating modular SPD equipment adjacent to associated electrical distribution equipment.

1.02 REFERENCES

- A. American National Standard Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1: IEEE Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits
 - 2. C62.45: Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- B. Military Standard (MIL):
 - 1. 220A: Radio Frequency Interference and Electromagnetic Interference
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250: Enclosures for Electrical Equipment (1000 volts maximum)
 - 2. LS 1: Low Voltage Surge Protection Devices
- D. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).

- E. Underwriters Laboratory (UL):
 - 1. 1449: Standard for Safety, Surge Protective Devices - Fourth Edition.
 - 2. 1283: Standard for Safety, Electromagnetic Interference Filters

1.03 SUBMITTALS

- A. Shop drawings, manufacturer's product data, and component ratings in accordance with this section and the requirements of Section 26 05 10 "Electrical Work – General".
- B. SPD type, model number, system voltage, phases, modes of protection, Maximum Continuous Operating Voltage (MCOV) Voltage Protection Rating (VPR), Short Circuit Current Rating (SCCR), and Nominal Discharge Current (In).
- C. Provide outline drawings and internal wiring diagrams.
- D. List all required installation criteria including circuit breaker trip rating to meet UL 1449, Four Edition.
- E. Identify all cable sizes, distance limits and accessory devices when SPD units are to be provided in separate enclosures, where applicable.
- F. For informational/purposes only, submit installation instructions and separate from all other submittals.
- G. UL 1449 listing and summary of factory test data.

1.04 QUALITY ASSURANCE

- A. SPD units and all components shall be designed manufactured and tested in accordance with the latest applicable UL Standard ANSI/UL 1449 Third Edition.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Provide in accordance with Section 26 05 10 "Electrical Work – General" and as specified.
- B. Shipping:
 - 1. Ship equipment and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.
 - 2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
 - 3. Deliver spare parts after installation but before start-up of system as specified. Deliver to Owner after completion of work.

C. Storage:

1. Inspect and inventory items upon delivery to site.
2. Store and safeguard equipment, material and spare parts.

1.06 WARRANTY AND SERVICE

- A. The SPD manufacturer is to warranty the components against defective materials and workmanship for a period of five years following delivery from the manufacturer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Surge Protection Device Components.

1. Eaton/Cutler-Hammer.
2. Schneider/Square D
3. Siemens.
4. General Electric Company.

2.02 PROVISIONS

A. Environmental Requirements:

1. Operating Temperature: minus 40 degrees C to 60 degrees C.
2. Relative Humidity: 5 to 95 percent.
3. Operating Altitude: 0 to 12,000 Feet (0 to 3,660 meters).
4. Audible Noise: Less than 35 dBA at 3 feet (1 m).

B. Electrical Requirements:

1. The maximum continuous operating voltage of all suppression components utilized is not to be less than 115 percent of the nominal operating voltage at the installed location.
2. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

<u>Volts</u>	<u>L-N</u>	<u>L-L</u>	<u>N-G</u>
208Y/120	460V	1000V	700V
480Y/277	1100V	1800V	1000V

3. The ANSI/IEEE C62.41.1-1991 Category C3 let through voltages shall not exceed the following

<u>Volts</u>	<u>L-N</u>	<u>N-G</u>
208Y/120	550V	470V
480Y/277	900V	920V

4. The SPD components are to be rated as follows:

480V Service Entrance at each Structure	250 kA per phase 125 kA per mode
480V Distribution Panels	160 kA per phase 80 kA per mode
120/208V Panelboards	120 kA per phase 60 kA per mode

5. The mode of operation is to protect against surges and transients as follows:

<u>System Configuration</u>	<u>Protection Mode</u>
Single Phase, Two Wire (L,N) + Ground	L to G,L to N, and N to G
Single Phase, Two Wire (L,L) + Ground	L to L, and L to G
Split Phase, Three Wire + Ground	L to L, L to G,L to N, and N to G
Three Phase, Three Wire (Delta) + Ground	L to L, and L to G
Three Phase, Four Wire (Wye) + Ground	L to L, L to G,L to N, and N to G

2.03 OPERATION

- A. The suppression system shall incorporate a hybrid designed Metal-Oxide Varistors (MOV) surge suppressor. The system shall not use silicone avalanche diodes, air gaps or other methods of suppression.
- B. Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 50 dB at 100 kHz.
- C. SPD shall provide surge current diversion between each phase conductor and the neutral conductor, between each phase conductor and ground and between the neutral conductor and ground. For delta systems, the SPD shall have components directly connected between each phase conductor and between each phase conductor and ground.
- D. The SPD shall provide a low impedance path for surge current using oversized conductors with equal impedance paths to each suppression element. Plug-in style connections or printed circuit boards for use in the path of surge current shall not be used.
- E. Operating Parameters:

1. The maximum response time shall not exceed 1 nanosecond.
2. Provide with a noise filtering system capable of managing noise levels produced by electro-magnetic interference and radio frequency interference. The noise filtering system shall reject a minimum of 50db at 100 kHz as measured by the 50 Ohm Insertion Loss Method (Military Standard 220A).
3. The parallel system components shall operate over a minimum frequency range of 47 Hertz to 63 Hertz.
4. The SPD components shall limit total harmonic distortion produced by the SPD to less than one percent.
5. SPD component ratings to be per UL 1449.
6. Each unit shall be factory tested at the maximum continuous operating voltage and short circuit tested, prior to delivery.

F. Product Components:

1. Protection and Filtering Elements:
 - a. The SPD components shall consist of replaceable protection modules designed to suppress and divert transient voltages and surge currents. Each protection module shall contain one or more individually fused metal oxide varistors capable of withstanding over 1000 surges of Category C (IEEE/ANSI C62.41.1) current rated at 10,000 amperes.
 - b. Each protection module shall contain filtering elements capable of providing noise attenuation.
 - c. The SPD components shall substantially limit transient waveform rise-time characteristics. The components are to be configured as parallel connected, current carrying elements designed to enhance the surge suppression and diversion performance of the protection modules.
2. Provide individual fusing to allow the SPD to be isolated during fault conditions.
3. Provide red and green solid-state status lights which indicate operational status of each unit and visual diagnostic monitoring of each component and module. Provide audible alarm to activate on fault condition, with a silence switch and push-to-test alarm switch.
4. Provide surge counter with battery backup to retain memory upon loss of AC power.
5. Provide remote status monitoring with form C dry contacts monitoring all phases.

2.04 SHOP TESTING

- A. Perform factory performance testing on each unit. The test to consist of the following:
 - 1. High voltage impedance test.
 - 2. Current test.
- B. Tests shall be in accordance with the following standards:
 - 1. ANSI/IEEE C62.41.1 Cat. A, B, & C.
 - 2. ANSI/IEEE C62.45.
 - 3. Military Standard 220A.
 - 4. Underwriters Laboratory UL 1449.
- C. Submit certified documentation of all factory tests performed.
- D. Perform above tests in addition to standard factory tests.

2.05 SPARE PARTS

- A. Provide in accordance with Section 01 78 23 "Operation and Maintenance Data" and as specified.
- B. Provide one spare protection module of each type for on-site spare parts purposes.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Visually inspect delivered unit(s) and accessories for conformance with drawings and specifications. Replace all components found to exhibit defects.

3.02 INSTALLATION

- A. Install unit in compliance with the manufacturers printed instructions. All electrical installation work shall be in accordance with UL Listing Requirements and applicable National or Local Electrical Codes.
- B. For units mounted adjacent to electrical distribution equipment, verify conduit and wire for the SPD components are as specified by the SPD manufacturer and installed in strict accordance with the National Electrical Code.
- C. Verify UL 1449, fourth edition, label is provided on each unit.

3.03 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 50 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide complete indoor lighting systems as indicated and in compliance with Contract Documents.
- B. Light fixture schedules are provided on the Contract Drawings. These Specifications are to be considered supplementary to the information contained in the light fixture schedule. In areas of conflict the scheduled items shall be provided.
- C. Fixtures shall be "Energy Star" rated.
- D. Provide a Ultraviolet (UV) Surface Disinfection Lighting System as stated in the specifications and as shown on the plans.

1.02 DEFINITIONS

- A. Emergency Lighting Unit: Fixture with integral emergency battery-powered supply and means for controlling and charging battery. Also known as an emergency light set.
- B. Fixture: Complete lighting unit, exit sign, or emergency lighting unit. Fixtures include lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply. Internal battery-powered exit signs and emergency lighting units also include battery and means for controlling and recharging battery. Emergency lighting units include ones with and without integral lamp heads.

1.03 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. C78.377: Chromaticity of Solid-State Lighting Products.
- B. Design Lights Consortium (DLC)
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
 - 2. 101: Life Safety Code.
- D. Underwriters' Laboratories, Inc., (UL):
 - 1. 773: Standard for Plug-In Locking Type Photo Controls for use with Area Lighting.

2. 773A: Nonindustrial Photo Electric Switches for Lighting Control.
3. 924: Standard for Emergency Lighting and Power Equipment.
4. 1598: UL Standard for Safety Luminaires
5. 8750: Light Emitting Diode (LED) Equipment for Use in Lighting Products.

E. Illuminating Engineering Society of North America (IESNA or IES):

1. LM-79: IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products
2. LM-80: IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources

1.04 SUBMITTALS

- A. Submit shop drawings and manufacturer's product data with installation instructions in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Submit manufacturer's shop drawings including photometric laboratory test data to show that luminaires proposed are of same type, construction and quality as those indicated. Luminaires are to be listed and labeled by Underwriters' Laboratories.
- C. Submit manufacturer's data for each ballast provided. Include detailed information for each luminaire showing wattage, voltage, and full load amp draw for each.
- D. Submit photometric calculations based on maintained lighting foot candle levels for areas where lighting fixtures are substituted. Substituted fixtures must provide similar lighting performance and energy usage as those scheduled, and must be constructed of similar quality and materials.

1.05 QUALITY ASSURANCE

- A. Provide in accordance with Section 01 43 00 "Quality Requirements" and as specified.
- B. Provide hangers and supports to resist failure from earthquake damage in accordance with NEC and all local and State codes.
- C. Lighting fixtures to be provided with dedicated supporting systems.
- D. Comply with the Code for Buildings and all local and State energy laws and regulations.

1.06 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least 1 of each type.
2. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least 1 of each type.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, except as indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:
 1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.
 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 2. Lens Thickness: 0.125 inches minimum; except where greater thickness is indicated.
- F. Fixture Support Components:
 1. Single Stem Hangers: 1/2 inches steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
 2. Twin Stem Hangers: Two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
 3. Rod Hangers: 3/8 inch minimum diameter, zinc plated, threaded steel rod.

4. Hook Hanger: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking type plug.

G. Provide EMI filters in each light fixture mounted in shielded enclosures.

1. Filters shall be integral to the fixture assembly with one filter per ballast.
2. Filters shall suppress electromagnetic interference in the AM radio band from 500 to 1700 kHz.

2.02 LED FIXTURES

- A. Provide fixtures on the Design Lights Consortium (DLC) Qualified Products List.
- B. Thermal Management: Liquids or other moving parts shall be clearly indicated in submittals, and shall be consistent with product testing.
- C. Color Rendering Index (CRI): >70.
- D. Correlated Color Temperature: 4000K.
- E. Minimum luminaire efficacies: 85 lumens per watt. Nominal input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.
- F. Fully enclosed wiring and LED diodes enclosed to prevent penetration of dust, insects, and other debris into the lamp and driver compartment.
- G. Driver/LED combined system shall have rated life based on IESNA LM-80-2008 (or latest) of 50,000 hours at 70% lumen maintenance.
- H. Driver is high efficiency type with THD < 20 percent and power factor > 0.90.

2.03 EMERGENCY LIGHTING AND EXIT LIGHTING UNITS

- A. Exit Signs: Conform to UL 924 and following:
 1. Sign Colors: Conform to local code.
 2. Minimum Height of Letters: Conform to local code.
 3. Arrows: Include as indicated.
- B. Emergency Lighting Units: Conform to UL 924. Provide self-contained units with following features:
 1. Battery: Sealed, maintenance free, lead acid type with minimum 10-year nominal life and special warranty. Battery shall be sized for a minimum of 90 minutes run time.

2. Charger: Minimum 2 rate, fully automatic, solid-state type, with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when supply circuit voltage drops to 80% of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep discharge level. Relay disconnects lamps and battery and automatically recharges and floats on trickle charger when normal voltage is restored. Provide test switch and operation light indication.
4. Wire Guard: Where indicated, provide heavy chrome plated wire guard arranged to protect lamp heads or fixtures.
5. Time Delay Relay: Provide time delay relay in emergency lighting unit control circuit arranged to hold unit ON for fixed interval after restoration of power after outage. Provide adequate time delay to permit HID lamps to restrike and develop adequate output.

2.04 ULTRAVIOLET SURFACE DISINFECTION LIGHTING SYSTEM

A. Manufacturer:

1. PURO Lighting
2. Approved Equal

B. Manufacturer and models are shown to establish standards. Equal products can be submitted for approval.

C. Lights:

1. Provide ceiling mounted, 120V, 60W, hard wire UV light with 24"x24" flange kit for drop-in ceiling mount.
2. PURO Helo F1 - H-F1-6-FC-COM-110 with H1-GA-24.

D. Control System:

1. Provide disinfection control system with Ethernet connectivity, motion detector, main control box, and two touch screens (one inside the lab and one on the wall outside the lab).
 - a. Main Control Box: Provide junction box with system controller, power supply, relay modules, and terminal blocks.
 - b. Motion Sensor: Provide wide-angle motion sensor with CAT5 connectivity.
 - c. In-Room Screen: Provide 3.5" x 5.25" minimum touch screen located in the room. Screen shall connect to the system via CAT5.

- d. External Screen: Provide 10” minimum touch screen located external to the room. Screen shall connect to the system via CAT5.
- 2. PURO Disinfection Control System - DCS-E-DT-x with motion detector(s) and touch screens.
- E. Commissioning:
 - 1. Provide commissioning by manufacturer approve and trained representative.
- F. Layout:
 - 1. The layout shown on the plans is for design intent only. Vendor shall provide calculations and layout which incorporates the lab layout with all equipment including all obstructions.
 - 2. Layout and calculations shall be submitted for approval including wiring diagram.
- G. Manufacturer's Warranty:
 - 1. Manufacturer agrees to repair or replace system components that fail in materials or workmanship within specified warranty period.
 - 2. Warranty Period: 60 months from date of Substantial Completion.

PART 3 - EXECUTION

3.01 LUMINAIRES AND LAMPS

- A. Install types and sizes indicated, complete. Deliver lamps of proper type, wattage and voltage rating to site and install in luminaires prior to completion of project.
- B. Install all luminaires to comply with applicable provisions of National Electrical Code. Suspend pendant luminaires by means of suitable outlet box cover-type aligners, each having flexible joint permitting unit to hang plumb.
 - 1. Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers.
 - 2. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.
 - 3. Brace pendants 4 feet or longer to limit swinging.
 - 4. Single-unit suspended fixtures shall have twin-stem hangers.

5. Multiple-unit or continuous row fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.
 6. Rods shall be a minimum 3/8-inch diameter.
- C. Use aligners of shock absorbing type, where indicated.
 - D. Use vaportight aligners with vaportight luminaires.
 - E. Install each explosion-proof pendant luminaire having stem longer than 12 inches, with explosion-proof swivel or flexible fitting permitting luminaire to hang plumb. Luminaires with stems shorter than 12 inches aligned by level outlet box mounting, explosion-proof swivels, or other acceptable means.
 - F. Install luminaires with adjustable fittings to permit alignment with ceiling panels. Install luminaires in fire-resistive type of suspended ceiling construction, equipped with fireproofing boxes constructed of materials of same fire rating as ceiling panels. Materials in conformance with UL approved building materials list.
 - G. Support for Recessed and Semi-recessed Grid Type Fixtures: Support Units from suspended ceiling support system. Install ceiling support system rods or wires at minimum of 4 rods or wires for each fixture, located not more than 6 inches from fixture corners.
 1. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner.
 2. Fixtures Smaller than Ceiling Grid: Install minimum of 4 rods or wires for each fixture and locate at corner of ceiling grid where fixture is located. Do not support fixtures by ceiling acoustical panels.
 3. Fixtures of Sizes Less than Ceiling Grid: Center in acoustical panel. Support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
 - H. Install accessories such as straps, mounting plates, nipples, or brackets necessary for proper installation.
 - I. Connect emergency light units to the unswitched branch circuit powering the luminaires in the same space.
- 3.02 CONTRACT CLOSEOUT
- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide complete outdoor lighting systems as indicated and in compliance with Contract Documents.
- B. Light fixture schedules are provided on the Contract Drawings. These Specifications are to be considered supplementary to the information contained in the light fixture schedule. In areas of conflict the scheduled items shall be provided.
- C. Fixtures shall be "Energy Star" rated.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A500/A500M: Cold Formed Welded and Seamless Carbon Steel Structural Tubing.
 - 2. B209/B209M: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - 3. B429/B429M: Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1: IEEE Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits
 - 2. C62.41.2: IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- C. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
- D. Underwriters' Laboratories, Inc. (UL):
 - 1. 773: UL Standard for Safety Plug-In Locking Type Photocontrols for Use with Area Lighting-Fourth Edition
 - 2. 844: UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations-Twelfth Edition

3. 1029: Standard for Safety High Intensity Discharge Lamp Ballasts.
4. 1598: UL Standard for Safety Luminaires

1.03 DEFINITIONS

- A. Fixture: Complete lighting device. Fixtures include lamp or lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply.
- B. Lighting Unit: Fixture or assembly of fixtures with common support, including pole or bracket plus mounting and support accessories.
- C. Luminaire: Fixture.

1.04 SUBMITTALS

- A. Submit shop drawings and manufacturer's product data with installation instructions in accordance with the requirements of Section 26 05 10 "Electrical Work – General".
- B. Submit manufacturer's shop drawings including photometric laboratory test data to show that luminaires proposed are of same type, construction and quality as those indicated. Luminaires are to be listed and labeled by Underwriters' Laboratories.
- C. Submit manufacturer's data for each ballast provided. Include detailed information for each luminaire showing wattage, voltage, and full load amp draw for each.
- D. Submit photometric calculations based on maintained lighting foot candle levels for areas where lighting fixtures are substituted. Substituted fixtures must provide similar lighting performance and energy usage as those scheduled, and must be constructed of similar quality and materials.
- E. Product Data:
 1. Describe fixtures, lamps, ballasts, poles, and accessories. Arrange Product Data for fixtures in order of fixture designation. Include data on features, poles, accessories, finishes, and following:
 - a. Outline drawings indicating dimensions and principal features of fixtures and poles.
 - b. Electrical Ratings and Photometric Data: Certified results of laboratory tests for fixtures and lamps.
- F. Operating and Maintenance Data (O&M): Maintenance data for products to include operation and maintenance information.

1.05 QUALITY ASSURANCE

- A. Comply with IEEE C2.

- B. Items provided under this section shall be listed or labeled labelled by UL or other Nationally Recognized Testing Laboratory (NRTL).
 - 1. Term “NRTL” shall be as defined in OSHA Regulation 1910.7.
 - 2. Terms “listed” and “labeled” shall be as defined in National Electrical Code (NEC), Article 100.
 - C. Regulatory Requirements:
 - 1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.
 - D. Fixtures for Hazardous Locations: Conform to UL 844. Provide units that have Factory Mutual Engineering and Research Corporation (FM) certification for indicated class and division of hazard.
- 1.06 STORAGE AND HANDLING OF POLES
- A. Store poles on decay resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation.
 - B. Metal Poles: Retain factory applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.
- 1.07 EXTRA MATERIALS
- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. Glass and Plastic Lenses, Covers, and Other Optical Parts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.01 FIXTURES AND FIXTURE COMPONENTS

- A. Metal Parts: Free from burrs, sharp edges, and corners.
- B. Sheet Metal Components: Corrosion resistant aluminum, except as otherwise indicated. Form and support to prevent warping and sagging.
- C. Housings: Rigidly formed, weather and light tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed fixtures.

- D. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange for door opening to disconnect ballast.
- E. Exposed Hardware Material: Stainless steel.
- F. Reflecting Surfaces: Minimum reflectances as follows, except as otherwise indicated:
 - 1. White Surfaces: 85 percent
 - 2. Specular Surfaces: 83 percent
 - 3. Diffusing Specular Surfaces: 75 percent
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- H. Lenses and Refractors: Materials as indicated. Use heat and aging resistant, resilient gaskets to seal and cushion lens and refractor mounting in fixture doors.

2.02 LED FIXTURES

- A. Provide fixtures on the Design Lights Consortium (DLC) Qualified Products List.
- B. Thermal Management: Liquids or other moving parts shall be clearly indicated in submittals, and shall be consistent with product testing.
- C. Color Rendering Index (CRI): >70.
- D. Correlated Color Temperature: 4000K.
- E. Minimum luminaire efficacies: 85 lumens per watt. Nominal input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.
- F. Fully enclosed wiring and LED diodes enclosed to prevent penetration of dust, insects, and other debris into the lamp and driver compartment.
- G. Driver/LED combined system shall have rated life based on IESNA LM-80-2008 (or latest) of 50,000 hours at 70 percent lumen maintenance.
- H. Driver is high efficiency type with THD < 20 percent and power factor > 0.90.
- I. Outdoor fixtures capable of reliable operation in temperature range of -30 degrees C to +40 degrees C minimum.

2.03 FIXTURE SUPPORT COMPONENTS

- A. Pole Mounted Fixtures: Conform to AASHTO LTS-6.
- B. Wind load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus fixtures indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 mi./h (160 km/h) with gust factor of 1.3.
- C. Arm, Bracket, and Tenon Mount Materials: Match poles' finish.
- D. Mountings, Fastenings, and Appurtenances: Corrosion resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution.
- E. Poles: As indicated in Lighting Fixture Schedule.
- F. Pole Bases: Anchor type with galvanized steel hold-down or anchor bolts, leveling nuts, and bolt covers.
- G. Concrete for Pole Foundations:
 - 1. Comply with Section 03 30 00 "Cast-in-Place Concrete".
 - 2. Use 3000 psig (20 MPa) strength, 28 day concrete.

2.04 FINISHES

- A. Metal Parts: Manufacturer's standard finish, except as otherwise indicated, applied over corrosion resistant primer, free of streaks, runs, holidays, stains, blisters, and similar defects.
- B. Other Parts: Manufacturer's standard finish, except as otherwise indicated.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Set units plumb, square, level, and secure according to manufacturer's written instructions and accepted submittals.
- B. Concrete Foundations: Construct according to Section 03 30 00 "Cast-in-Place Concrete".
 - 1. Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor bolt templates by comparing with actual pole bases furnished.
 - 2. Finish: Trowel and rub smooth parts exposed to view.

- C. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.
- D. Fixture Attachment: Fasten to indicated structural supports.
- E. Fixture Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.
- F. Lamp fixtures with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.

3.02 GROUNDING

- A. Ground fixtures and metal poles according to Section 26 05 26 "Grounding and Bonding for Electrical Systems".
 - 1. Poles: Install 10 feet (3 m) driven ground rod at each pole.
 - 2. Nonmetallic Poles: Ground metallic components of lighting unit and foundations. Connect fixtures to grounding system with No. 6 AWG conductor.

3.03 FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged fixtures and components.
- B. Tests and Observations:
 - 1. Give advance notice of dates and times for field tests.
 - 2. Replace or repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until units operate properly.

3.04 ADJUSTING AND CLEANING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.

3.05 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 27 05 53

IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Labels.
2. Bands and tubes.
3. Underground-line warning tape.
4. Signs.
5. Cable ties.
6. Miscellaneous identification products.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Labels.
2. Bands and tubes.
3. Underground-line warning tape.
4. Signs.
5. Cable ties.
6. Miscellaneous identification products.

B. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

C. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.

3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- D. Comply with NFPA 70 and TIA 606-B.
- E. Comply with ANSI Z535.4 for safety signs and labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.02 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 1. Black letters on a white field.

2.03 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, vinyl flexible labels with acrylic pressure-sensitive adhesive.
 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

2. Marker for Labels:

- a. Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Minimum Nominal Size:

- a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
- b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
- c. As required by authorities having jurisdiction.

2.04 BANDS AND TUBES

- A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

2.05 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE"
3. Foil Core Thickness: 0.35 mil (0.00889 mm).
4. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
5. Tensile According to ASTM D882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

C. Tag, Detectable, Reinforced:

1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Width: 3 inches (75 mm).
3. Overall Thickness: 8 mils (0.2 mm).
4. Foil Core Thickness: 0.35 mil (0.00889 mm).
5. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
6. Tensile According to ASTM D882: 300 lbf (1334 N) and 12,500 psi (86.1 MPa).

2.06 SIGNS

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, high-intensity reflective, punched for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches (250 by 360 mm).

C. Laminated-Acrylic or Melamine-Plastic Signs:

1. Engraved Legend: With black letters on white face.
2. Thickness:
 - a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
 - b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.

3. Attachment: Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.07 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) According to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) According to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) According to ASTM D638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.08 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.02 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- H. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
 - 3. Provide label 6 inches (150 mm) from cable end.

I. Snap-Around Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches (150 mm) from cable end.

J. Self-Adhesive Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches (150 mm) from cable end.

K. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.03 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.

- C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
 - 1. System legends shall be as follows:
 - a. Telecommunications.
- D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:
 - 1. Wiring closet designation.
 - 2. Colon.
 - 3. Faceplate number.
- E. Equipment Room Labeling:
 - 1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
 - 2. Patch Panels: Label individual rows in each rack, starting at top and working down, with self-adhesive labels.
 - 3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
 - a. Room number being served.
 - b. Colon.
 - c. Faceplate number.
- F. Backbone Cables: Label each cable with a vinyl-wraparound label] indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.
- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:
 - 1. Room number.
 - 2. Colon.
 - 3. Faceplate number.

- H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
- I. Instructional Signs: Self-adhesive labels.
- J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Metal-backed, butyrate warning signs.
 - 1. Apply to exterior of door, cover, or other access.
- K. Equipment Identification Labels:
 - 1. Indoor Equipment: Self-adhesive label.
 - 2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign.
 - 3. Equipment to Be Labeled:
 - a. Communications cabinets.
 - b. Network Racks
 - c. Uninterruptible power supplies.
 - d. Fire-alarm and suppression equipment.
 - e. Egress points.

END OF SECTION

SECTION 27 11 16

COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:

- 1. 19-inch freestanding and wall-mounted equipment racks.
 - 2. 19-inch freestanding and wall-mounted equipment cabinets.
 - 3. Power strips.
 - 4. Grounding.
 - 5. Labeling.

- B. Related Requirements:

- 1. Section 26 05 26 "Grounding and Bonding for Electrical Systems".
 - 2. Section 26 05 36 "Cable Trays for Electrical Systems" for cable trays and cable tray accessories.
 - 3. Section 27 15 13 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.

1.03 DEFINITIONS

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. BICSI: Building Industry Consulting Service International.
- C. LAN: Local area network.
- D. RCDD: Registered communications distribution designer.
- E. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

- F. TGB: Telecommunications grounding bus bar.
- G. TMGB: Telecommunications main grounding bus bar.

1.04 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.
- B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 - 3. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.
- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- D. Seismic Qualification Data: Certificates, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD.

2. Installation Supervision: Installation shall be under direct supervision of Installer 2, Copper or Fiber, who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as Technician to perform on-site inspection.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
- B. UL listed.
- C. RoHS compliant.

2.02 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 06 10 00 "Rough Carpentry."

2.03 19-INCH EQUIPMENT RACKS

- A. Description: four-post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72-inches (450-mm) between rails.
- B. General Requirements:
 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 2. Material: Extruded steel.
 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 4. Color: Black.
- C. Floor-Mounted Racks:
 1. Overall Height: 72 inches (1828.8 mm).

2. Overall Depth: 23 inches (584.2 mm).
3. Upright Depth: 3 inches (76.2 mm)
4. Four-Post Load Rating: 1000 lb (454 kg).
5. Number of Rack Units per Rack: 38.
 - a. Numbering: Every rack units, on interior of rack.
6. Threads: 10-32.
7. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
8. Base shall have a minimum of four mounting holes for permanent attachment to floor.
9. Top shall have provisions for attaching to cable tray or ceiling.
10. Self-leveling.

D. Wall-Mounted Racks:

1. Height: 36 inches (914.4 mm).
2. Depth: 24 inches (609.6 mm).
3. Load Rating: 200 lb (91 kg).
4. Number of Rack Units per Rack: 12.
5. Threads: 10-32.
6. Wall Attachment: Four mounting holes.
7. Equipment Access: Integral swing.

E. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.04 19-INCH EQUIPMENT CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72 inches (450 mm) between rails.
- B. General Cabinet Requirements:
 - 1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Material: Extruded steel.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 - 4. Color: Black.
- C. Modular Freestanding Cabinets:
 - 1. Overall Height: 72 inches (1828.8 mm).
 - 2. Overall Depth: 23 inches (584.2 mm).
 - 3. Load Rating: 3000 lb (1362 kg).
 - 4. Number of Rack Units: 38.
 - a. Numbering: Every rack units, on interior of rack.
 - 5. Threads: 10-32.
 - 6. Removable and lockable side and top panels.
 - 7. Hinged and lockable front doors with viewing window. Rear shall be open.
 - 8. Adjustable feet for leveling.
 - 9. Screened ventilation openings in roof and rear door.
 - 10. Cable access provisions in roof and base.
 - 11. TGB.
 - 12. Roof-mounted, 550-cfm (260-L/s) fan with filter.
 - 13. Power strip.
 - 14. All cabinets keyed alike.

D. Modular Wall Cabinets:

1. Height: 22 inches (558.8 mm).
2. Depth: 23 inches (584.2 mm).
3. Load Rating: 200 lb (91 kg).
4. Number of Rack Units: 12.
5. Threads: 10-32.
6. Lockable front doors with viewing window.
7. Louvered side panels.
8. Cable access provisions top and bottom.
9. Grounding lug.
10. Roof-mounted, 250-cfm (118-L/s) fan.
11. Power strip.
12. All cabinets keyed alike.

E. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at top of each relay rack, with a minimum height of two rack units each.

2.05 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting.
3. Six 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
4. LED indicator lights for power and protection status.

5. LED indicator lights for reverse polarity and open outlet ground.
6. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
7. Cord connected with 15-foot (4.5-m) line cord.
8. Rocker-type on-off switch, illuminated when in on position.
9. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
10. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than 330 V.

2.06 GROUNDING

- A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Rack and Cabinet TGBs: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-B. Predrilling shall be with holes for use with lugs specified in this Section.
 1. Cabinet-Mounted TGB: Terminal block, with stainless-steel or copper-plated hardware for attachment to cabinet.
 2. Rack-Mounted Horizontal TGB: Designed for mounting in 19-inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 3. Rack-Mounted Vertical TGB: 72 or 36 inches (1828.8 or 914.4 mm) long, with stainless-steel or copper-plated hardware for attachment to rack.

2.07 LABELING

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout of communications equipment spaces.
- C. Comply with BICSI ITSIMM for installation of communications equipment spaces.

- D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- E. Coordinate layout and installation of communications equipment in racks and room. Coordinate service entrance configuration with service provider.
 - 1. Meet jointly with system providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
 - 2. Record agreements reached in meetings and distribute them to other participants.
 - 3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment spaces to accommodate and optimize configuration and space requirements of telecommunications equipment.
 - 4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.
- F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.02 GROUNDING

- A. Comply with NECA/BICSI 607.
- B. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" Ch.
- C. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches (50 mm) of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground. Connect rack TGB to near TGB or the TMGB.
 - 1. Bond the shield of shielded cable to patch panel, and bond patch panel to TGB or TMGB.

3.03 IDENTIFICATION

- A. Coordinate system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Section 27 0 553 "Identification for Electrical Systems."
- B. Labels shall be machine printed. Type shall be 1/4 inch (6 mm) in height.

END OF SECTION

SECTION 27 13 23

OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide fiber optic cables as indicated and as specified.
- B. Fiber optic cables shall be provided for use with plant-wide systems, including the plant SCADA network as detailed on the Contract Drawing Network Architecture Diagram.
- C. Provide fiber optic patch panels, splice closures, terminal connectors and ancillary equipment.
- D. Provide fiber optic pull boxes based on fiber optic cable with a maximum allowable pulling tension of 600 lbs (2700 N). Provide calculations for pulling with innerduct shop drawing submittal.
- E. Provide innerduct, distribution pedestals, terminal connectors and ancillary equipment needed for a complete installation.

1.02 REFERENCES:

- A. American National Standards Institute (ANSI):
 - 1. TIA-568C: Generic Telecommunications Cabling for Customer Premises
 - 2. TIA/EIA 598-C: Optical Fiber Cable Color Coding.
 - 3. TIA/EIA 606-A: Administration Standard for Commercial Telecommunications Infrastructure
- B. Insulated Cable Engineers Association, Inc. (ICEA):
 - 1. S-104-696: Standard for Indoor-Outdoor Optical Fiber Cable.
- C. International Electrical Testing Association (NETA):
 - 1. ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- D. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).

E. Underwriters Laboratories, Inc. (UL):

1. 94: UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
2. 1666: UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

1.03 DEFINITIONS:

- A. OFNR: Nonconductive optical fiber riser cable.
- B. OFCR: Conductive optical fiber riser cable.
- C. FOTP: Fiber Optic Test Procedure.

1.04 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00:

1. Installer Qualifications - Include resumes of staff and previous project experience with references. Proposed Products List.
2. Outline drawings of termination cabinets showing dimensions, cables, jumpers and associated hardware for termination.
3. Provide written confirmation that product is to be submitted as acceptable to control systems supplier.
4. For each component and material submit shop drawing which shall include:
 - a. Manufacturer.
 - b. Model number.
 - c. General data and description.
 - d. Engineering specifications and data sheets.
 - e. Catalog cuts.
 - f. For information purposes only, submit manufacturer's printed installation instructions.

B. Submit a drawing showing the routing for the fiber optic network. Include the following information:

1. Routing, length, and attenuation based on TIA-568-C.

2. Cable and conduit identification.
 3. Locations of manholes, pull boxes, pedestals and patch panels.
- C. Test Documentation:
1. Document results of tests (shop test, field test, acceptance test) and submit copies of documents to the Engineer as tests are completed.
- 1.05 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
 - B. Furnish two spare connectors for each type used.
- 1.06 QUALITY ASSURANCE:
- A. Provide in accordance with Section 01 43 00 and as specified.
 - B. Fiber optic cables and related equipment shall be the products of approved manufacturers. Fabrication of the fiber optic cables and related equipment shall utilize the most advanced commercial materials and manufacturing processes. Manufacturer shall be ISO 9001 and TL 9000 certified.
 - C. Fiber optic cable installation shall be performed by experienced fiber optic cable installers who shall have been regularly engaged in the installation of fiber optic cables for the last five years at the minimum. The installer shall be MDIS certified with current qualifications provided by the fiber optic cable manufacture.
 - D. Fiber optic cable splicing and terminations shall be performed by experienced cable splicers who shall have been regularly engaged in splicing and termination of fiber optic cables for the last five years at the minimum.
 - E. Provide the services of the fiber optic cable manufacturer's technical representative to certify that the fiber optic cable installation is in accordance with the manufacturer's installation requirements.
 - F. Provide the services of an independent testing firm who shall perform acceptance testing of the fiber optic cable installation. The testing firm shall have experience in the inspection and testing of cables of the specified type and shall be a member company of NETA.
- 1.07 DELIVERY, STORAGE AND HANDLING:
- A. Provide in accordance with Section 01 66 10 and as specified.

1.08 EQUIPMENT IDENTIFICATION:

- A. Each fiber shall be labeled at each termination point and all splice location. Conductor or circuit identification shall be applied at specified points with circuit numbers or other identification stamped on terminal boards when provided, or on the cable itself in such a manner that the identification is visible around the cable's circumference.
- B. Each fiber shall be identified in junction boxes, pull boxes, manholes, handholes, terminal boxes, and cabinets. Where no termination is made, use a plastic-coated, self-adhesive, wire marker. Where termination is made, use a plastic, pre-printed sleeve wire marker. Paper self-adhesive wire markers are not acceptable.

1.09 WARRANTY:

- A. The Contractor shall be a manufacturers' certified installer and shall provide a five-year extended warranty program; and shall also provide written warranty certification and evidence of current program membership.
- B. The Contractor shall warrant that all materials and equipment furnished under the contract are in good working order, free from defects, and in conformance with system specifications. All installed equipment shall conform to the manufacturer's official published specifications. The warranty shall begin at the system acceptance date and remain in effect for a period of five years from that date. The Contractor shall agree to repair, adjust, and/or replace (as determined by the Engineer to be in its best interest) any defective equipment, materials, or other parts of the system at the Contractor's sole cost. The Owner will incur no costs for service or replacement of parts during the warranty period of five years. All third party warranties shall be passed through from the Contractor to the Owner.
- C. The Contractor shall warrant and supply evidence that the installation of materials and hardware will be made in strict compliance with all applicable provisions of the National Electrical Code (NEC), the rules and regulations of the Federal Communications Commission, and state and/or local codes or ordinances that may apply.
- D. The Contractor shall warrant that the system will function in accordance with the manufacturer's published technical description guide.
- E. The Contractor shall warrant that the system shall accommodate traffic at the levels specified in the Specification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Corning Cable Systems.
- B. Belden.

C. Draka.

D. OFS Fiber.

2.02 FIBER OPTIC CABLE:

A. Single Mode Fiber Optic Cable:

1. Provide indoor/outdoor tight bound tight buffered fiber optic cable. Provide gel free and powder free tight buffered water block cable. Provide cable fiber count as indicated on the drawings. Provide cable that shall pass the TIA 455 83B water block test for 48 hours.
2. Provide Single Mode fiber optic cable as specified and as shown on the contract drawings.
3. Provide optical fiber proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m²).
4. Provide fiber that meets the following minimum specifications in 12 fiber subgroups as:

Feature Performance	Specification Requirement
Fiber Type	Single Mode
Core Diameter	9 µm
Cladding Diameter	125 µm
Secondary Buffer Diameter	900 µm
Wavelength	1310 nm
Gigabit Ethernet Distance	2 km
Max Attenuation	1 dB/km
Cable Diameter	~15 mm (30 fiber count)
Installation:	
Max Tensile Load	~5600 N
Min Bend Radius	~23 cm
Operating:	
Max Tensile Load	~2400 N
Min Bend Radius	~23 cm
Operating Temperature	-40 degrees C to +85 degrees C
Installation Temperature	-10 degrees C to + 60 degrees C
Flame Retardancy	UL Listed

B. Fiber Optic Non-Breakout Cable:

1. Heavy duty, tight buffer construction with additional strength members, and an oil, water, and chemical resistant, UV stabilized, flame retardant, PVC outer jacket, UL

listed OFNR. Fiber cladding shall be 125 micron and fiber buffer shall be 900 micron.

2. Cable specifications:

- a. Fiber Count: 12
- b. Minimum Installation Load: 100 lbs (450 N).
- c. Minimum Long Term Application Load: 14 lbs (63 N).
- d. Minimum Crush Resistance: 80 lbs/inch (3.2 kg/cm).
- e. Operating Temperature: 14 to 122 degrees F (-10 to 50 degrees C).

C. Code Compliance:

- 1. The cable must meet the requirements of the National Electrical Code (NEC) Section 770.
- 2. Non-Plenum Applications: Applicable Flame Tests: UL 1666. All-dielectric cables shall be listed OFNR. Armored cables and Interlocking armored cables shall be listed OFCR.
- 3. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Indoor-Outdoor Optical Fiber Cable (ICEA S-104-696).

D. Fiber Specifications:

- 1. General Fiber Specifications:
 - a. All fibers in the cable must be usable and meet required specifications.
 - b. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
 - c. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m²).
 - d. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.

E. Cable Construction:

- 1. Tight Buffer Fiber Optic Cable: Cladded Optic fiber strands shall be coated with a 900 microns protective coating and arranged in a PVC Subcable containing 12 coated fiber strands surrounded by yarn strength members. Subcables are contained

within a PVC Outer jacket. The number of strands specified on the drawings will determine the number of Subcables.

2. Fiber Optic Cable Core: A central, nonmetallic core member shall be included to serve as a cable core foundation to reduce strain on the fibers, but not to serve as a pulling strength member. Fillers shall be used to ensure cable has a circular shape. Fiber optic cable and subcables shall have a rip cord.
3. Each buffer tube shall contain up to 12 fibers.
4. The fibers shall not adhere to the inside of the buffer tube.
5. Each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598-C, "Optical Fiber Cable Color Coding."
6. The fibers shall be colored with ultraviolet (UV) curable inks. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature ranges, and not subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.
7. Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with TIA/EIA-598-C, "Optical Fiber Cable Color Coding." Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 0.04 inch. For dual layer buffer tube construction cables, standard colors are used for tubes 1 through 12 and standard colors with stripes are used to denote tubes 13 through 24. The color sequence applies to tubes containing fibers only, and shall begin with the first tube. The tube color sequence shall start from the inside layer and progress outward.
8. The buffer tubes shall be resistant to kinking.
9. The cable shall contain at least one ripcord under the sheath for easy sheath removal.
10. The tensile strength shall be provided by the central member, and additional dielectric yarns. The dielectric yarns shall be helically stranded evenly around the cable core.
11. A flame-retardant tape may be applied to provide additional resistance to flame propagation for higher fiber count cables.
12. Cables shall be sheathed with flame-retardant polyvinyl chloride (PVC). The nominal jacket thickness shall be 0.08 inch. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The PVC shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

13. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable.
14. Cable jackets shall be marked with the manufacturer's name or file number, month and year of manufacture, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code (NESC[®]), fiber count, and fiber type, flame rating and listing marking. The actual length of the cable shall be within +/- 1 percent of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 0.1 inch.
15. If the initial marking fails to meet the specified requirements (i.e., improper text statement, color, legibility, or print interval), the cable may be remarked using a contrasting alternate color. The numbering sequence will differ from the previous numbering sequence, and a tag will be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color will be yellow, the secondary choice will be blue.
16. The maximum pulling tension shall be 600 lb (2,700 N) during installation (short term) and 135 lb (600 N) long-term installed.
17. The cable specified herein shall be available in three sheath designs. Un-armored, all-dielectric cables shall be listed OFNR and shall be as described previously in this section.
18. Armored cables shall be as described previously in this section, but shall also include a corrugated steel tape armor applied longitudinally underneath the cable jacket. The armor shall be plastic-coated on both sides for corrosion resistance and shall have an overlapping seam with the corrugations in register. Because of the metallic armor, this cable shall be listed OFCR and shall provide improved resistance to rodent damage. The corrugated armor option will be specified on the purchase order.
19. Interlocking armored cables shall be as described previously in this section but shall also include an interlocking steel or aluminum armor applied helically around the outside of the cable jacket. The interlocking armor may be left un-jacketed or may have a PVC outer jacket. The color of the armor jacket (if specified), shall match the jacket color of the optical fiber cable located inside of the armor. The armor for these cables shall be comparable to liquid tight flexible metal conduit if jacketed, or flexible metal conduit if not jacketed. Because of the interlocking metallic armor, this cable shall be listed OFCR and shall provide improved resistance to crush damage. The interlocking armor and outer jacket options will be specified on the purchase order.

F. Packing and Shipping:

1. The completed cable shall be packaged for shipment on non-returnable wooden reels. Required cable lengths shall be stated in the purchase order.
2. Top and bottom ends of the cable shall be available for testing.
3. Both ends of the cable shall be sealed to prevent the ingress of moisture.
4. Each reel shall have a weather resistant reel tag attached identifying the reel and cable.
5. Each cable shall be accompanied by a cable data sheet.

2.03 INNERDUCT:

A. Manufacturers:

1. Carlon.
2. Innerduct.
3. A-D Technologies

B. Features:

1. 2 inch (50 mm) smooth wall HDPE role pipe innerduct designed for fiber optic cabling and telecommunications.
2. System shall include:
 - a. Innerduct.
 - b. Gasketing that allows watertight assembly and disassembly of outer and innerducts for direct buried and encased installations.
 - c. Couplings, access hole terminators, innerduct seals for both empty and cabled ducts, and fixed and flexible bends.

2.04 TERMINAL CONNECTORS:

A. Manufacturers:

1. Corning Cable Systems.
2. AFL Telecommunications.
3. 3M Telecom Systems Group.

- B. Field installable LC type fiber optic connectors, with ceramic ferrule material and a maximum insertion loss of 0.5 dB. If Pre-Connectorized cable assemblies or pigtails are used, the connectors shall terminate on a 3.0 m (10-foot) length single-fiber cable. The fiber-cable shall contain a buffered optical fiber of the same type and specification as that used in the multi-fiber cable. Connectors and pre-connectorized cable assemblies or pigtails shall be in accordance with EIA ANSI/TIA/EIA-568-B.3.

2.05 OPTICAL HARDWARE:

A. Manufacturers:

1. Corning Cable Systems.
2. 3M Telecom Systems.
3. AFL Telecommunications AMP
4. OCC.

B. Optical Slicing and Distribution Enclosure:

1. Provide pedestal type enclosure.
2. Provide NEMA 3 fiber enclosure.
3. Provide pedestal mounted on precast concrete base with bollard type traffic protection.
4. Provide splicing and distribution enclosure to support up to 240 single mode fibers.
5. Provide distribution hub within pedestal. Provide hub with grommet seal. Provide cable strain relief system.

C. Connector Panels: Rack and wall mountable connector housings shall accept an interchangeable connector panel. A connector panel is defined as a modular removable plate containing optical fiber connector adapters or copper jacks. The connector panel shall have the following characteristics:

1. The connector panel shall utilize a single mounting footprint and shall be available with three, four, six, eight or twelve connector adapters in each panel. Copper jack panels shall accept up to four copper jacks. The connector panel shall be interchangeable between the rack and wall mountable hardware being proposed. The panel shall be attached with two push-pull latches to allow quick installation and removal.
2. The connector panel shall be available with industry standard single fiber and small form factor multi-fiber adapters, utilizing only LC connectors. It shall also be available with industry standard copper jacks.

3. The connector panel shall include removable icons that identify the circuits. As a minimum, these icons shall be available with the following symbols: blank, telephone, computer, CATV, video camera, satellite dish, or CAT5. The icons shall also be available in a variety of colors, including blue, yellow, red, white, electric ivory, ash, green, purple, gray, black, brown and orange.
 4. Blank connector panels shall be available to fill unused space within the housings. The blank connector panel shall be attached with at least two push-pull latches to allow quick installation and removal. Housings shall be supplied with blank connector panels for all available positions unless the housing is ordered with optical fiber adapters or copper jacks pre-installed. The blank panels shall be manufactured from injection molded polycarbonate and shall be finished with a wrinkled black texture to match the housing.
 5. Panels shall be manufactured from 16 gage cold rolled steel or injection molded polycarbonate for structural integrity.
 6. Panels shall be finished with a wrinkled black texture to match other hardware.
- D. Connector Modules: Rack mountable connector housings shall accept an interchangeable connector module. A connector module is defined as a modular removable case containing optical fiber connector adapters and provisions for strain-relief, slack storage, and the furcation of fiber optic cables. The connector module shall have the following characteristics:
1. The connector module shall consist of a panel incorporated into a protective case with a removable cover for access to the interior connectors and fibers. Modules shall contain a fiber-retaining spool for managing fiber slack.
 2. The connector module shall utilize a single mounting footprint and shall be available with three, four, six, eight or twelve connector adapters in each module. The module shall be attached with two push-pull latches to allow quick installation and removal.
 3. The connector module shall be available with industry standard single fiber and small form factor multi-fiber adapters, utilizing only LC connectors.
 4. The connector module shall include removable icons that identify the circuits. As a minimum, these icons shall be available with the following symbols: blank, telephone, computer, CATV, video camera, satellite dish, or CAT5. The icons shall also be available in a variety of colors, including blue, yellow, red, white, electric ivory, ash, green, purple, gray, black, brown and orange.
 5. Modules shall be manufactured from 16 gage cold rolled steel or injection molded polycarbonate (or thermoplastic resin) for structural integrity.
 6. Modules shall be finished with a wrinkled black texture to match other hardware.

7. Modules shall be available in the following configurations: adapter modules, pigtailed modules, and pre-terminated system modules.
- E. Rack Mountable Connector Housings: Rack mountable connector housings shall be available for cross-connecting or inter-connecting purposes. The units shall provide for direct connectorization and pigtail splicing.
1. The unit shall meet the design requirements of ANSI/TIA/EIA-568 and the plastics flammability requirements of UL 94 V-0.
 2. Housings shall be manufactured using 16 gage aluminum or equivalent for structural integrity and shall be finished with a wrinkled black powder coat for durability. Installation fasteners shall be included and shall be black in color.
 3. The unit shall have routing guides that allow a transition and segregation point for jumpers exiting the sides of the housing.
 4. The unit shall include a clamshell-type cable clamping mechanism to provide cable strain relief. The cable clamp shall accept one cable from 0.37 to 1.13 inch in diameter. The cable clamp mechanism shall also handle multiple smaller fiber count cables when used with the multiple cable insert. The total cable capacity per clamp shall be five cables less than 0.4 inch OD when used with the multiple cable insert.
 5. The connector housings shall have a labeling scheme that complies with ANSI/TIA/EIA 606.
 6. Provisions for mounting fiber fan-out devices shall be incorporated into the housing.
 7. The housings shall be available with factory installed connectorized cable stubs in multiple cable and connector types.
- F. Wall Mountable Combination Connector/Splice Housings: Wall mountable combination connector and splice housings shall be available for splicing inside the same housing as the connectorized fiber. These combination units shall be the units described in the previous section for wall mountable connector housings; additionally they shall contain provisions for mounting splice trays and routing the associated fibers.
1. Splice tray mounting shall allow individual splice tray access without disturbing adjacent splice trays or fibers.
 2. Splice tray shall be retained in the splice tray holder by a hook and loop strap.
 3. Access to splice trays shall be accomplished by rotating the splice tray holder horizontally from the housing.
 4. Wall mountable connector housings shall be convertible to combination connector/splice housings with the installation of a splice tray conversion kit.

- G. Wall Mountable Splice Housings: Wall mountable splice housings shall be available for splicing multiple optical fiber cables. These units shall contain provisions for mounting splice trays and routing the associated fibers.
1. Splice tray mounting shall allow individual splice tray access without disturbing adjacent splice trays or fibers.
 2. Splice trays shall be retained in the splice tray holder by a hook and loop strap.
 3. Cable ports in the splice housing shall line up with the cable and jumper ports in the appropriate wall mountable connector housing so as to allow direct routing of cables and jumpers from one housing into the other.
 4. Wall-mountable splice housing shall accept splice trays for industry standard splice types and store routing slack for these trays.
 5. The unit shall be mountable on standard plywood walls.
 6. The housing shall not exceed the following dimensions:
 - a. 13.5 inch (343 mm) high x 22.5 inch wide x 5.1 inch deep.
 7. The unit shall meet the design requirements of ANSI/TIA/IEA-568 and the plastics flammability requirements of UL 94 V-0.
 8. Housing shall be manufactured using 16 gage (1.6 mm) aluminum or equivalent for structural integrity and shall be finished with a wrinkled black powder coat for durability. Assembly hardware and equipment attaching machine screws shall be included and shall be black in color.
 9. The unit shall have fiber cable routing guides that allow a transition and segregation point for fibers existing the top and bottom of the housing. Cable entries shall be grommets to minimize dust/water intrusion.
 10. The unit shall accept a clamshell type cable clamping mechanism to provide cable strain relief. This clamp shall be included with the housing and also shall be available with an external mounting bracket as an optional accessory. The cable clamp shall accept one cable from 0.37 to 1.13 inch in diameter. The cable clamp mechanism shall also handle multiple smaller fiber count cables when used with the multiple cable insert. The total cable capacity per clamp shall be five cables less than 0.4 inch OD when used with the multiple cable insert. Housing cable clamp capacity shall be at least four clamps.
 11. The splice housing shall have a metal door. This door shall be lockable when used with an optional key lock kit.
 12. The splice housings shall have a labeling scheme that complies with ANSI/TIA/EIA 606.

13. Brackets shall be available that allow rack mounting of the wall-mount housings.
 14. An optional offset bracket kit shall be available that allows mounting the housing away from the wall to give space for cable routing behind the unit. The offset brackets shall be stackable to allow incremental increase in the amount of offset from the wall.
- H. Wall Mount Jumper Management: Wall mountable housings shall have an optional external means available to transition between the housing and nearby cable trough or tray. This means shall provide 38 mm minimum bend radius protection for cables.

2.06 SPLICE CLOSURES:

A. Manufacturers:

1. Corning Cable Systems.
2. 3M Telecom Systems, Group.
3. AFL Telecommunications.

B. Splice Closures: Constructed of thermoplastic, suitable for “butt” or “through” cable entry, moisture tight sealing arrangement, removable splice tray organizer, splice trays for mechanical splices, suitable for single mode system operation at 1,310 and 1,550 nm, grounding lugs or equivalent for grounding cable armor.

1. The optical fiber splice closure shall meet all requirements stated in this specification.
2. The splice closure housing shall be non-metallic. It shall be resistant to solvents, stress cracking, and creep. The housing materials shall also be compatible with chemicals and other materials to which they might be exposed in normal applications.
3. The optical fiber closure shall be capable of accepting any optical fiber cable used in interoffice, outside plant, and building entrance facilities.
4. As an option, the ability to double the cable capacity of an installed canister splice closure by use of a kit shall be available. Such a conversion shall not disturb existing cables or splices.
5. Encapsulation shall not be required to resist water penetration.
6. The splice closure shall be re-enterable. The closure end cap shall be capable of accepting additional cables without removal of the sheath retention or strength member clamping hardware on previously installed cables or disturbing existing splices. The optical fiber splice closure shall provide a clamping mechanism to

prevent pistoning of the central member or strength members and to prevent cable sheath slip or pullout.

7. The splice closure shall have appropriate hardware and installation procedures to facilitate the bonding and grounding of metal components in the closure and the armored cable sheath. The cable bonding hardware shall be able to accommodate a copper conductor equal to or larger than a 6 AWG.
8. Aerial splice closures shall have available the necessary hardware to attach and secure the closure to an aerial strand.
9. The closure shall accommodate splice trays suitable for single fiber, single fiber heat shrink, mechanical, or ribbon heat shrink splices.
10. The small splice closure shall accommodate up to 72 single fiber splices or 144 ribbon fiber splices using 12-fiber ribbons. The medium sized closure shall accommodate up to 288 single fiber splices or 432 ribbon fiber splices. The large closure shall accommodate up to 480 single fiber splices or 864 ribbon fiber splices.
11. Spliced fibers shall not be subjected to a bend radius smaller than 1.2 inch. Buffer tubes shall not be subjected to a bend radius smaller than 1.5 inch.
12. The installation of the splice closure shall not require specialized tools or equipment, other than those normally carried by installation crews.

2.07 SHOP TESTS:

- A. Fiber optic cables shall be shop tested at the manufacturer's plant in accordance with the manufacturer's standard testing procedures. Shop tests shall be performed prior to shipment of the fiber optic cables.
- B. Provide test plan defining all tests required to ensure that the system meets specified requirements. The test plan shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plan shall identify the capabilities and functions to be tested.
- C. Provide test reports in booklets form showing all field tests performed shall be submitted no later than 7 days after completion and testing of the installed system.
- D. Measurements shall be tabulated on a strand-by-strand basis.
- E. Factory test results showing routine tests performed by the manufacturer shall be submitted prior to installation.
- F. Optical fibers in cables shall be 100 percent attenuation tested. The attenuation shall be measured at 850 nm and 1300 nm for multimode fibers. The attenuation shall be measured at 1310 nm and 1550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of five years. These values shall be available upon request.

- G. The Contractor shall submit manufacturer's shop test reports.

PART 3 - EXECUTION

3.01 GENERAL

- A. Provide all material, equipment, and labor to install the fiber optic cables as indicated and as specified.
- B. Installation shall be in accordance with the National Electrical Code and all local codes.

3.02 INSTALLATION:

- A. Install cables in accordance with manufacturer's printed instructions.
- B. Install cable directly from shipping reels. Ensure that cable is not:
 - 1. Dented, nicked, or kinked.
 - 2. Subjected to pull stress greater, or bend radius less, than manufacturer's specification.
 - 3. Subjected to treatment which may damage fiber strands during installation.
- C. Conduit: Install fiber optic cable directly in conduit/innerduct.
- D. Identification: Identify each cable on both ends and in all manholes and pull points it goes through.
- E. Sequencing: Provide cables in accordance with sequencing requirements.
- F. Sealing: Seal cables into innerducts to stop ingress of water and grit with expansion plugs or ductseal.
- G. Manholes:
 - 1. Provide supports for cables at maximum 12 inch centers along sides of manholes.
 - 2. Provide a minimum 4 foot coil of spare fiber in each manhole throughout the cable length.
- H. Install fiber optic cables in underground ducts. Rod and swab out ducts prior to installing cables.
- I. Install fiber optic cables in the conduit systems provided inside buildings and structures.
- J. Lubricate cables with lubricants specially formulated for fiber cabling jackets during installation. Do not exceed cable manufacturer's specifications for tensile strength and

bending radius. All pulleys used to aid in the installation of the fiber optic cable must be sized according to the minimum bending radius.

- K. Provide breakout kits, splice closures, patch panels, pigtails, and jumpers and as indicated to install a complete data highway communications network as indicated. Patch panels shall be wall mounted plumb and level. Splice closures shall be installed in pullboxes.
- L. Splices: Splices shall be made only where indicated. Provide adequate put-up lengths on cable reels to make termination-to-termination runs without splices. Where splices are indicated provide mechanical splices with attenuation losses of 0.3 dB or less. Make splices watertight and provide mechanical protection equal to the cable jacket, or better.
- M. Support cables in riser conduits at intervals as required by the National Electrical Code.
- N. Installation tools and materials shall be provided by the cable manufacturer.
- O. The polishing process of terminal connectors shall be a multi-stage dry and wet process using multiple lapping films for initial and final polishing polish.

3.03 CABLE TERMINATIONS:

- A. Terminate cables in accordance with ANSI/TIA 568.
- B. Fan out fibers to allow flexibility and ease of installations for future expansion at connection points. Provide a metal or high density plastic fan-out collar to relieve the stress on the individual fibers. To protect the individual fibers, provide sleeves from the fan-out collar to the terminal point. Terminate all fibers in each cable with a suitable connector as specified below.
- C. Fiber connectors shall be bayonet-type with “twist-lock” mounting for quick and secure installation. Connectors shall be pull-proof with a durable ceramic tip to protect the fibers from damage during installation and frequent rearrangements. “Push-pull” couplings are unacceptable. Provide a sample of the connector to the Engineer for inspection and acceptance prior to installation.
- D. Provide all equipment, mounting kits and consumable materials required for a proper installation as defined by the manufacturer.
- E. Each individual cable shall be clearly and uniquely identified. At a terminal cabinet or backboard provide a type written directory listing the cable, identification code and type of signal. The directory shall be mounted within the termination cabinet or on the backboard and protected by a clear plastic cover.
- F. Provide a minimum of 20 feet of neatly coiled, slack fiber optic cable at each terminal cabinet or backboard for flexibility.

3.04 MANHOLES, INTERMEDIATE PULL BOXES AND DISTRIBUTION PEDESTALS:

- A. Provide pull boxes and manholes so the fiber pulling requirement is at least 5 percent below the manufacturers pulling strength recommendations. Provide pulling procedures as part of the fiber installation submittal requirements:
- B. Provide plans showing proposed pull boxes, manholes and distribution pedestals.
- C. Provide distribution pedestal at the beginning and end point of the contract installation.
- D. Provide fiber testing from the contract endpoint distribution pedestals.

3.05 PHYSICAL CHECKOUT:

A. General Procedures:

- 1. Conduct physical checkout of the fiber optic data highway network.
- 2. Physical checkout shall be performed prior to functional testing.

B. Check Procedures:

- 1. Verify that fiber optic cables reels have been off-loaded from truck carefully and not damaged.
- 2. Verify that the optical fibers of the cable assembly are the type and quantity as specified or as recommended by the supplier.
- 3. Verify that cable construction is the type specified.
- 4. Verify that fiber optic patch panels have been installed plumb and level at locations indicated.
- 5. Verify that fiber optic splice closures have been installed at locations indicated.
- 6. Verify that optical fiber connections or terminations within patch panels and splice closures are in accordance with cable manufacturer's printed recommendations.

3.06 FIELD TESTING:

A. Conduct the following field tests after cable installation:

- 1. Visually, inspect terminal connectors for out-of-round condition and surface defects such as micro-chips and cracks using a 100X (minimum) inspection microscope.

B. Cable Testing:

1. Provide equipment, instrumentation, and supplies necessary to perform testing. Engineer and Owner shall have the option to witness and participate actively in on-site tests.
 - a. Notify Engineer and Owner at least 3 days prior to testing.
2. Perform all tests and inspections as required by NETA ATS, paragraph 7.25.
3. Post-Installation Testing: Demonstrate that all fibers in each cable meet requirements of TIA-568 as modified here:
 - a. Maximum attenuation as specified.
 - b. Measure attenuation in both directions, not in one direction only.
4. Replace all cables or mated connector pairs that do not meet attenuation standards and redo tests until cable meets requirements and at no additional cost to the Owner.

3.07 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 27 15 13

COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Shielded twisted pair (STP) cabling.
2. Multiuser telecommunications outlet assemblies.
3. Cable connecting hardware, patch panels, and cross-connects.
4. Telecommunications outlet/connectors.
5. Cabling system identification products.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
2. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
3. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings Cabling Administration Drawings, and field-testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site. Test each pair of STP cable for open and short circuits.

PART 2 - PRODUCTS

2.01 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.
 - 1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.

2.02 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 450 or less.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Grounding: Comply with J-STD-607-A.

2.03 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm).

2.04 STP CABLE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. ADC.
 - 2. Belden Inc.
 - 3. Berk-Tek; a Nexans company.
 - 4. Approved Equal
- B. Description: 100-ohm, four-pair STP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
 - 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 - 3. Comply with TIA/EIA-568-B.2, Category 6.
 - 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

- a. Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG.
- b. Communications, Plenum Rated: Type CMP or MPP, complying with NFPA 262.
- c. Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, complying with UL 1666.
- d. Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG.
- e. Multipurpose: Type MP or MPG; or MPP or MPR.
- f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
- g. Multipurpose, Riser Rated: Type MPR or MPP, complying with UL 1666.

2.05 STP CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. ADC.
 - 2. American Technology Systems Industries, Inc.
 - 3. Belden Inc.
 - 4. Approved Equal
- B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
- E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.
- F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- G. Patch Cords: Factory-made, four-pair cables in 48-inch (1200-mm) lengths; terminated with eight-position modular plug at each end.
 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.

2.06 CONSOLIDATION POINTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. American Technology Systems Industries, Inc.
 2. Belden Inc.
 3. Chatsworth Products, Inc.
 4. Approved Equal
- B. Description: Consolidation points shall comply with requirements for cable connecting hardware.
 1. Number of Terminals per Field: One for each conductor in assigned cables.
 2. Number of Connectors per Field:
 - a. One for each four-pair STP cable indicated.
 - b. One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
 3. Mounting: Wall.
 4. NRTL listed as complying with UL 50 and UL 1863.
 5. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.07 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Belden Inc.
 - 2. Chatsworth Products, Inc.
 - 3. Hubbell Premise Wiring.
 - 4. Approved Equal
- B. Description: MUTOAs shall meet the requirements for cable connecting hardware.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
 - 2. Number of Connectors per Field:
 - a. One for each four-pair STP cable indicated.
 - b. One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
 - 3. Mounting: Wall.
 - 4. NRTL listed as complying with UL 50 and UL 1863.
 - 5. Label shall include maximum length of work area cords, based on TIA/EIA-568-B.1.
 - 6. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.08 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
- B. Workstation Outlets: Two-port-connector assemblies mounted in single faceplate.
 - 1. Metal Faceplate: Stainless steel.
 - 2. For use with snap-in jacks accommodating any combination of STP work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
 - 3. Legend: Machine printed, in the field, using adhesive-tape label.

2.09 GROUNDING

- A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Comply with J-STD-607-A.

2.10 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11 SOURCE QUALITY CONTROL

- A. Factory test STP cables on reels according to TIA/EIA-568-B.1.
- B. Factory test STP cables according to TIA/EIA-568-B.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.02 WIRING METHODS

- A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters. Conceal pathways and cables except in unfinished spaces.
- B. Wiring within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 2. Install lacing bars and distribution spools.
 - 3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.03 INSTALLATION OF CABLES

- A. All cable terminations to be completed by manufacturer or manufacturer approved installer.

B. Comply with NECA 1.

C. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. MUTOA shall not be used as a cross-connect point.
5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for STP at least 49 feet (15 m) from communications equipment room.
6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. STP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist STP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend STP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B for separating shielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and shielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
3. Separation between communications cables in grounded metallic raceways and shielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.04 FIRESTOPPING

- A. Comply with TIA-569-B, Annex A, "Firestopping."
- B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.05 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with J-STD-607-A.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.06 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A.
 1. Administration Class: 2.
 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

- B. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
- C. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
 - 6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.
- F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.07 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visually inspect STP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test STP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. STP Performance Tests:
 - a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
 - (1) Wire map.
 - (2) Length (physical vs. electrical, and length requirements).
 - (3) Insertion loss.
 - (4) Near-end crosstalk (NEXT) loss.
 - (5) Power sum near-end crosstalk (PSNEXT) loss.
 - (6) Equal-level far-end crosstalk (ELFEXT).
 - (7) Power sum equal-level far-end crosstalk (PSELFEXT).
 - (8) Return loss.

(9) Propagation delay.

(10) Delay skew.

- B. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.08 DEMONSTRATION

- A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION

SECTION 28 10 00

ACCESS CONTROL AND VIDEO SURVEILLANCE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Access Control system.
2. Video Surveillance system

B. Products Installed, but Not Furnished, under This Section:

1. See Section 08 71 00 "Door Hardware" for the following:
 - a. Electric strike(s).
 - b. Electromagnetic lock(s).
 - c. Delayed-egress electromagnetic lock(s).
 - d. Electromechanical lock(s).
 - e. Self-contained electronic lock(s).
 - f. Exit lock(s) and alarm(s).
 - g. Auxiliary electrified door hardware.

1.02 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman - type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. DGP: Data gathering panel.
- F. FTP: File transfer protocol.
- G. IP: Internet protocol.
- H. LAN: Local area network.

- I. MPEG: Moving Picture Experts Group.
- J. NFC: Near field communications.
- K. NTSC: National Television System Committee.
- L. PC: Personal computer.
- M. PTZ: Pan-tilt-zoom.
- N. RAID: Redundant array of independent disks.
- O. REX: Request-to-exit.
- P. TCP: Transmission control protocol - connects hosts on the Internet.
- Q. UPS: Uninterruptible power supply.
- R. WAN: Wide area network.

1.03 QUALITY ASSURANCE

- A. The system shall be furnished and installed by Stone Security. Contact:

Jonny Burton
Account Manger
351 W. Lawndale Drive
Salt Lake City, UT 84115
jonny@stonesecurity.net
Tel: 877.888.0129
Cell: 801.857.4811
www.stonesecurity.net

- B. Contractor:

- 1. Shall be fully and solely responsible for the work of the systems supplier and solely responsible to the Owner for having supplied to the Owner the complete system.
- 2. To provide personal superintendence and direction to the work, maintaining and supplying complete supervision over and coordination between all subcontractors employed by him.
- 3. To be responsible for defining the limits of his subcontractor's work.

- C. Technical services:

- 1. Provide supervisory service of a factory trained service engineer, specifically trained on the type of equipment herein specified, during construction to assist the Contractor in the location of sleeves, methods of installing conduit and special cable,

mounting, piping, and wiring of one of each type of service, and the methods of protecting all of the equipment prior to placing it into service.

2. Upon completion of equipment installation, provide services of the above service engineer for a period of not less than ten 8-hour days for calibration and start-up of the equipment and instructing the operating personnel.
3. The minimum days specified above do not relieve the system manufacturer of providing sufficient service to place the system in satisfactory operation.

1.04 SUBMITTALS

A. Shop Drawings:

1. Project general notes.
2. Head-end hardware, equipment, and device locations.
3. Block diagram and cable/conduit routing illustrating end-to-end system wiring.
4. End-to-end system communications details.
5. Secondary power calculations.
6. Battery calculations.

B. Field Quality-Control Submittals:

1. Field quality-control reports.

C. Sample warranties.

D. Manufacturers' Published Instructions and Manuals: Record copy of official installation instructions and manual for each piece of equipment

E. Warranty documentation.

1.05 REGULATORY AGENCY APPROVALS

- A. Submittals for access control system requiring approval by authorities having jurisdiction must be signed and sealed by qualified life safety professional engineer responsible for their preparation.
- B. Submittals for access control system require action by Architect prior to submitting for approval by authorities having jurisdiction.

1.06 WARRANTY FOR ACCESS CONTROL SYSTEM

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed access control system performs in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Manufacturer and model numbers are listed per owner standards. Provide updated equipment of equal or better quality and/or functions where model numbers or owner standards have changed.
- B. Provide quantities of each piece of equipment as required for a complete and operating system.

2.02 ACCESS CONTROL SYSTEM EQUIPMENT:

- A. Access Control and CCTV Power Supply
 - 1. Provide 16 door, 4-amp, 12VDC and 24VDC, 16 lock and 16 auxiliary distribution outputs Access Control and CCTV power supply in UL listed indoor electrical enclosure. Life Safety Power # FPO150-B1002C82D8E4.
 - 2. Provide 12VDC, 12AH batteries. Altronix BT1212.
- B. Network Node
 - 1. Provide wall mounted Network Node with extension blades. S2 Security S2-NN-E2R-WM and S2-ACM.
- C. Keypad/Card Reader
 - 1. Provide reader with Signo 40 Smartcard Keypad Reader, Multi-Technology, Mobile Ready, Wall Switch Mount, Pigtail, Black/Silver. HID Global 40KNKS-T0-000000.
- D. Request-to-exit
 - 1. Provide REX exit motion sensor with sounder, door monitor and trim plate. Bosch Security Systems DS160 and TP160.

E. Door Sensor

1. Provide 1” recessed, steel door contact, white door sensors. GRI Telemark Corp. 184-12-W.

F. Cabling

1. Provide 4 Element Access Control Cable 18-04 + 22-3P OAS + 22-02 + 22-04 Plenum White Jacket. Windy City Wire 446100.
2. Provide 15’ Patch Cables, CAT6, PVC. Windy City Wire.

2.03 VIDEO SURVEILLANCE EQUIPMENT:

A. Cameras:

1. Fixed Indoor Dome Camera: 1080 HDTV / 2MP, IR, 3.4-8.9mm lens, Vandal, Lightfinder 2.0, Forensic WDR, Zipstream, H.265, Two-way Audio, I/O, DLPU, SD Slot. Axis P3265-LV.
2. Fixed Outdoor Dome Camera: HDTV 1080 2MP Vandal Resistant, Optimized IR 9mm. Axis P3265-LVE.
3. Outdoor/Indoor, Fixed Multi-sensor Dome, 8MP, 4x1080P 12.5 / 15FPS or 4 x 720P Full Frame, IR, Forensic WDR, Lightfinder, SD Slot. Axis P3727-PLE.

B. Camera Mounts:

1. Pendant Kit for P32-VE Series, fits directly to 1.5" threaded pipe. Axis T94T01D.
2. Wall Bracket for P33-V/VE Series, Q35-V/VE Series 1.5" NPS thread for fixed dome pendant kits. Includes white mounting plate, pipe seal and conduit hole cover. Axis T91D61.
3. Pendant Kit for AXIS P3717-PLE / P3719-PLE / P3727-PLE, IP Camera, 1.5-inch NPS thread. Axis T94N01D
4. Wall Mount designed with a built-in RJ45 cable and connection, 1.5" NPS thread, Compatibility with all pendant kits for Axis Fixed Dome Cameras. Axis T91H61.
5. Corner Bracket (requires T91D61 Wall Bracket) for Axis P55-series, Q60-series, P33-series Pendant Kit. Axis T91A64.

C. Cabling

1. Provide CAT6, Unshielded, Solid, Plenum, White. CommScope CS34P WHT
2. Provide 7’ Patch Cables, CAT6, PVC. Windy City Wire.

3. Provide power over Ethernet extender where needed. Axis T8129.

PART 3 - EXECUTION

3.01 INSTALLATION OF ACCESS CONTROL SYSTEM

- A. Description: Access control system provides a means of regulating or controlling physical entry into an area, or access to or use of a device by electrical, electronic, and/or mechanical means. Typical access control system includes a card reader at a controlled door, which reads a user credential and sends the collected data to a centrally located DGP over the cabling infrastructure. DGP may hold a user database onboard or may communicate with a user database over the network. If user is authorized for access at a controlled door, DGP signals the electronic lock at the door to unlock. If user credential is not authorized according to user database, the door remains locked and access is denied. In addition to card readers and electronic locks, access control systems may include various other connected devices programmed for a desired function.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Components listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.
- C. Selection of Access Control System Components:
 1. Source Limitations: Obtain components for access control system from sources approved by Installer warranting performance of entire system.
- D. Special Techniques:
 1. Comply with manufacturer's published instructions.
 2. Mounting Heights: Mount field devices in accessible locations in accordance with United States Access Board ADA-ABA Accessibility Guidelines standards.
- E. Interfaces with Other Work:
 1. Coordinate with Section 08 71 00 "Door Hardware" for interfacing access control system devices with door hardware.

3.02 WIRING

- A. Wiring Method: Install cables in raceways unless otherwise indicated.

1. Conceal raceways and wiring except in unfinished spaces.
 2. Minimum raceway shall be 3/4".
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- C. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.03 VIDEO SURVEILLANCE INSTALLATION

- A. Install cameras and infrared illuminators level and plumb.
- B. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms and adjust.
- D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- E. Avoid ground loops by making ground connections only at the control station.
1. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.
- F. Identify system components, wiring, cabling, and terminals according to Section 27 05 53 "Identification for Communications Systems."

3.04 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by owner or owner's representative.
- B. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections for access control system components.
 2. Perform industry standard tests and inspections for power supplies, batteries, and other standby power provisions.

3. Engage factory-authorized service representative to test end-to-end system connection and functionality.
 4. Verify monitoring of access control system status and diagnostics information.
- C. Nonconforming Work:
1. Access control equipment will be considered defective if it does not pass tests and inspections.
 2. Video surveillance system will be considered defective if it does not pass tests and inspections.
 3. Remove and replace defective units and retest.
- D. Collect, assemble, and submit test and inspection reports.
- E. Tests and Inspections Video Surveillance:
1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
 2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - a. Prepare equipment list described in "Informational Submittals" Article.
 - b. Verify operation of auto-iris lenses.
 - c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. Verify operation of control-station equipment.

3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

3.05 SYSTEM STARTUP

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's published instructions.

3.06 ADJUSTING

- A. Control Sensor Adjustments: Adjust control devices to suit actual occupied conditions.
 1. For proximity motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.07 PROTECTION

- A. After installation, protect access control system components from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.08 MAINTENANCE

- A. Control Sensor Readjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
 1. Check cable connections.
 2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
 3. Adjust all preset positions; consult Owner's personnel.
 4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
 5. Provide a written report of adjustments and recommendations.

3.09 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION

SECTION 28 31 00

FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide fire detection and alarm as indicated and in compliance with Contract Documents.
- B. Provide, test, and place into operating condition an electrically operated, microprocessor based, UL listed, four-wire, analog/addressable, electrically supervised fire detection and evacuation system as indicated and specified.
- C. The System shall include, but not be limited to: Fire Alarm Control Panel (FACP), Remote Annunciator Command Center (ACC), power supplies and fire alarm initiating and notification devices including addressable monitor and control modules.
- D. The fire alarm system shall include conduit, wire, fittings, and accessories required to provide a complete operating system.
- E. Connect fire alarm control panels in a local area network via twisted pair cable for data communication with other areas. Display local information at each network node and the entire network monitored at the network remote annunciator panel.
- F. All charges and fees required by the local Authority having jurisdiction (AHJ) to inspect the installation and implement fire alarm notification are to be included by the Contractor under this section at no additional cost to the Owner.
- G. System shall include a voice evacuation panel in compliance with NFPA 72 requirements.

1.02 REFERENCES:

- A. ASME International (ASME):
 - 1. A17.1: Safety Code for Elevators and Escalators
- B. Factory Mutual (FM):
 - 1. P7825: Approved Guide
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1: IEEE Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits.

2. C62.41.2: IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.

D. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).
2. 72: National Fire Alarm Code
3. 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
4. 101: Life Safety Code.

E. Underwriters' Laboratories (UL)

1. Fire Protection Equipment Directory
2. 268: Standard for Smoke Detectors for Fire Alarm Signaling Systems
3. 464: Standard for Audible Signal Appliances
4. 864: Control Units for Fire Protective Signaling Systems
5. 1971: Signaling Devices for the Hearing Impaired

G. State and Local Building Codes.

1.03 SYSTEM DESCRIPTION:

A. Type of System:

1. Fire Alarm System: The fire alarm system shall operate as a low voltage analog/addressable type system and shall automatically initiate fire alarm signals whenever any manual or automatic fire detecting devices are placed into an alarm mode. The system shall indicate areas of alarm and sound local alarms. Initiating loops and notification loops shall be wired as four-wire class A loops. Initiating loops and notification loops shall be complete with necessary switches, meters, relays, pilot lights, surge arresters and addressable modules as required. A minimum of one thermal cut-out or fuse and surge arrestor for every notification circuit shall be provided. An annunciator shall indicate the specific location of the fire.
2. The system shall be capable of operating with a single break or ground fault condition in the initiating or alarm sounding circuits.
3. Evacuation Alarms: Coded evacuation alarm: A fire alarm signal shall be employed for notifying the occupants to evacuate.

4. Trouble Signals: During abnormal conditions such as an open wire or a ground fault, or where both conditions occur at one point, the system shall be capable of automatically transmitting clear, intelligible trouble signals.
5. Power Supply for the System: A dedicated branch-circuit for supplying power to the alarm system shall be provided for the Fire Alarm Control Panel (FACP). The branch circuits shall be automatically energized from an auxiliary electrical power system during failures of the normal power supply. Provide battery backup power consisting of rechargeable, sealed type storage batteries and battery charger.
6. The system shall interface to HVAC system and other building systems as shown on the Contract Drawings and required by applicable codes to provide all required monitoring and control functions.

B. Sequence of Operation:

1. When a fire-alarm condition is detected by one of the system initiating devices, the following functions shall immediately occur:
 - a. Automatic programs assigned to the alarm point shall be executed and the associated indicating devices and relays activated.
 - b. Fire-alarm notification devices in the building shall operate.
 - c. The system alarm on the Fire Alarm Control Panel and Remote Annunciator Command Center will indicate condition.
 - d. The alarm shall be signaled automatically to an FM Approved company.
 - e. Shutdown of HVAC equipment and associated exhaust and pressurization operations to be initiated.
2. When a trouble condition is detected by one of the system initiating or indicating circuits, the following functions shall immediately occur:
 - a. System Trouble will be indicted on FACP and Annunciator Command Center.
 - b. A local trouble-sounding device in the FACP and Annunciator Command Control shall be activated. This sound shall be distinct from the alarm sound.
 - c. The appropriate message will appear on the LCD display at the FACP and Annunciator Command Center.

1.04 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Copy of this specification section with addenda and all referenced specification sections with addenda check-mark each paragraph to indicate specification compliance or indicate deviation and reason for deviation.
 - a. Failure to include a copy of the marked-up specification sections will result in return of the entire submittal with no further review and consideration.
2. Installer and system supplier qualifications and list of three similar projects with name and phone number of contact person.
3. Complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts. Shop drawings shall contain complete conduit riser diagrams, wiring diagrams, and schematic diagrams for the equipment furnished. Riser diagrams shall identify cable sizes and quantities, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit.
4. Manufacturer's printed installation instructions.
5. Battery capacity calculations to demonstrate that the battery size selected is a minimum of 125 percent of the calculated requirement. Calculation to include supervisory power requirements for all equipment, and alarm power requirements for all equipment.
 - a. Calculations to show amplifiers have sufficient capacity to simultaneously drive fire alarm speakers at their 1/2 watt tap plus 50 percent spare capacity.
6. Wiring diagrams from the fire alarm system integrator or supplier differentiating clearly between factory and field installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Identify all diagrams to be specific to this project and distinguish between field and factory wiring.

B. Spare Parts Data:

1. After approval of the list of shop drawings, and not later than six months prior to the date of substantial completion, furnish copies of spare parts data for each different item of materials and equipment specified. The data shall include a complete list of parts and supplies with current unit prices and source of supply, a list of supplies that are either normally furnished at no extra cost with the purchase of the equipment, or specified to be furnished in accordance with paragraph Special Tools and Spare Parts and a list of additional items recommended by the manufacturer to assure efficient operation for a period of 120 days.

C. Operating and Maintenance Instruction Manuals:

1. At end of project, submit operating instruction manuals as specified in 01 78 23, outlining the step-by-step procedures required for system startup and operation

shall be furnished. The instructions shall include the manufacturer's name, model number, service manual parts list and brief description of all equipment and their basic operating features.

2. Maintenance instructions manuals outlining maintenance procedures shall be furnished. The manual shall include a troubleshooting guide listing possible breakdown and repairs and a simplified connection wiring diagram for the system as installed. Provide the names, addresses, and telephone numbers of service organizations that provide technical assistance and carry stock of repair parts for the system to be furnished.
 3. Performance Test Reports: Upon completion of the installed system, submit in booklet form field tests performed to prove compliance with the specified performance criteria. Each test report shall indicate the final position of controls.
- D. Submit Certificate of Compliance, signed by manufacturers of fire alarm system components certifying that their products comply with specified requirements.
- E. Submission to Authorities Having Jurisdiction: In addition to routine submission of the above material, make an identical submission to the authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Upon receipt of comments from the authorities having jurisdiction, submit them for review. Resubmit if required to make clarifications or revisions to obtain approval.

1.05 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.
- B. Provide one spare FACP mother board and 10 percent or a minimum of 2 devices of the total devices provided for this Contract as listed below.
1. Pull Stations.
 2. Manual Pull Stations
 3. Weatherproof Smoke Detectors.
 4. Photoelectric Smoke Detectors.
 5. Thermal Detectors, 135 degrees F (57 degrees C).
 6. Thermal Detectors, 190 degrees F (88 degrees C).
 7. Alarm Audible Devices.
 8. Alarm Strobes.

- C. Three sets of special tools necessary for the maintenance of the equipment shall be furnished. Two spare sets of fuses of each type and size required and five spare lamps for each type shall be furnished. Spare parts shall be listed on submittal list.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Standard Products: Material and equipment shall be the latest standard products of a single manufacturer regularly engaged in the manufacture of the product for the 5 years as a minimum.
- C. Qualifications of the installer before commencing work: Submit information demonstrating that the supplier has successfully installed fire alarm systems of the same scope, type and design as specified.
 - 1. Submit copies of all required Licenses and Bonds as required by the AHJ. Employ on staff a minimum of one full time NICET level 2 Technicians or a professional engineer.
 - 3. Certify that the completed system conforms with UL standards upon completion of the installation.
 - 4. Ongoing maintenance and testing shall be provided to the Owner under a maintenance contract to maintain the UL listing.
- D. Nameplates: The components of equipment shall have the manufacturer's name, address, type or style, and catalog number on a plate securely attached to the equipment.
- E. Tags: Tags with stamped identification number shall be furnished for keys and locks. Tags shall be furnished to identify cable and conduit runs, wiring circuits, and all spare parts furnished for Authority's stock to maintain the system.
- F. Keys and Locks: All locks shall be keyed alike.
- G. Verification of Dimensions: Become familiar with details of the work and verify dimensions in the field.
- H. Compliance: The fire detection and internal alarm system shall be configured in accordance with NFPA 72. The equipment furnished shall be compatible and be UL listed or FM approved in accordance with the applicable NFPA standards.
- I. Accessibility: Enclosures shall be provided with ample gutter space to allow proper clearance between the enclosure and live parts of the panel equipment. If more than one modular unit is required to form a control panel, the units shall be installed in a single cabinet large enough to accommodate all units, and allow ample gutter space for interconnections of panels and field wires.

- J. Verify conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier.
 - K. Review selected arrangement with local fire authority for conformance with local and state requirements.
 - L. Onsite Technician Services:
 - 1. Provide the services of a representative or technician certified by the manufacturer of the system, experienced in the installation and operation of the type of system provided.
 - 2. The representative shall be licensed in the State if required by law.
 - 3. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system, and Underwriters Laboratories listing certification requirements.
 - 4. The technician shall provide the required instruction to the Owner's personnel in the system operation, maintenance and programming.
 - 5. Provide services of the manufacturer's service representative during installation, startup and testing, for a period of three working days plus travel where a working day is equivalent to 8 hours.
- 1.07 DELIVERY, STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.
 - B. Equipment placed into storage shall be protected from the weather, humidity and temperature variations, dirt, dust, and other contaminants.
- 1.08 SEISMIC DESIGN REQUIREMENTS:
- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
 - B. It shall be the responsibility of the manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Notifier

- B. Honeywell
- C. Simplex – Grinnell
- D. Or Approved Equal

2.02 MATERIAL AND EQUIPMENT:

A. General Product Description:

1. Each Fire-Alarm Control Panel (FACP) shall be capable of fire detection, equipment supervision and control, alarm management, and historical data collection and archiving.

B. Communications:

1. The FACP shall have sufficient memory to support its operating system and databases including:
 - a. Fire management
 - b. Alarm management
 - c. Historical/Trend Data
 - d. Maintenance Support Applications
 - e. Custom Processes
 - f. Operator I/O
2. Communication Ports: Provide data communication ports for simultaneous operation of devices such as industry standard printers, programming terminal, PC, transponder and annunciator.
3. Integrated On-Line Diagnostics: The FACP shall continuously perform self-diagnostics, communication diagnostics and diagnostics on all subsidiary equipment.
4. Surge and Transient Protection: Isolation shall be provided at all field point terminations to suppress induced voltage transients where required. Surge arrestors shall provide protection from all non-signal electrical surges that could cause damage to the equipment. Line surge arrestors shall be isolated from the electrical circuitry that they are protecting.

C. System Software Features:

1. Provide software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this section shall be provided as an integral part of the panel and shall not be dependent upon any higher level computer for execution.
3. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. The control unit shall have capability of performing alarm analysis and signaling. At no time shall the panel's ability to report alarms be affected by operator activity.
4. Status Change Report: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.
5. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided.
6. Report Routing: Alarm reports shall be archived for future recall.
7. Alarm Messages: In addition to the point's description and the time and date, the user shall be able to print, display or store a custom alarm message to more fully describe the alarm condition or direct operator response.
8. The FACP shall be capable of storing a library of at least 900 events.
9. History Mode:
 - a. The system shall be able to store and display at least 900 system events that have occurred in a non-volatile buffer memory. Display of these events shall be accomplished on-site through the use of the front control panel indicators and switches.
10. Field Configurable:
 - a. The system shall be fully configurable and expandable without the need for EPROM programmers. All configurations shall be accomplished through downloading of programs from a computer. Reconfiguration shall not require knowledge of any programming languages or require any special training. All programs shall be stored in non-volatile memory. Entry into program mode shall require a special key and a special password entered into the front panel.

D. Analog Device Interface:

1. The Analog Device Interface will be capable of supporting devices as indicated on drawings with 25 percent spare slots for future devices.

2. The analog addressable device interface shall contain its own microprocessor control.
3. The analog addressable device interface shall communicate and provide power to all devices on its loop over a single pair of wires. The fire-alarm system shall function as a Class A system.
4. The analog interface board shall receive analog information from intelligent detectors and shall process this information to determine normal, alarm, or trouble conditions. The analog information may also be used for automatic test and determination of maintenance requirements.
5. Communication with connected devices shall be performed every 5 seconds or less. Average time to detect an alarm shall be less than 10 seconds (longer for alarm verification detectors).

E. Notification Appliance Circuit:

1. The FACP shall provide supervised Class A notification circuits as indicated on drawings with 50 percent spare capacity for future devices. The circuit capacity shall be 2.0 amperes maximum per circuit, maximum of 8.0 amperes from the FACP's power supply. If a short-circuit trouble occurs on one of the circuits, it will not affect the operation of the remaining circuits.

F. Amplifiers, Preamplifiers, Tone Generators:

1. Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 shall be housed in a fire alarm control unit, terminal cabinet, or in the fire alarm control panel. The system shall automatically operate and control all building fire alarm speakers except those installed in the stairs and within elevator cabs. The speakers in the stairs and elevator cabs shall operate only when the microphone is used to deliver live messages. Each amplifier shall have two channels; one to broadcast a message and the other for paging.
 - a. Construction: Amplifiers shall utilize computer grade solid state components and shall be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.
 - b. Inputs: Each system shall be equipped with separate inputs from the tone generator, digitalized voice driver and panel mounted microphone. Microphone inputs shall be of the low impedance, balanced line type. Both microphone and tone generator input shall be operational on any amplifier.
 - c. Tone Generator: The tone generator shall be of the modular, plug-in type with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces. The tone generator shall

produce a slow whoop tone, which shall slowly ascend from low (500 Hertz) to high (1200 Hertz), and shall be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. Each slow whoop cycle shall last approximately 4 seconds. The tone generator shall be single channel with an automatic backup generator per channel such that failure of the primary tone generator cause the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay.

- d. Protection Circuits: Each amplifier shall be constantly supervised for any condition which could render the amplifier inoperable at its maximum output. Failure of any component shall cause automatic transfer to a designated backup amplifier, illumination of a visual “amplifier trouble” indicator on the control panel, appropriate logging of the condition of the system printer, and other actions for trouble conditions as specified.

G. Function Relays:

1. The FACP shall provide of Form “C” relay contacts, quantity as required, rated at 2 A at 120 VAC. These relays may be programmed to activate on alarm from any initiating zone or any combination of initiating zones, analog devices or addressable modules.

H. Central Processing Unit (CPU):

1. The CPU shall communicate with the operator interface, LCD display, LED display and control other modules in the panel. Removal, disconnection or failure of any control panel shall be detected and reported by the Central Processing Unit.
2. The CPU shall contain and execute all control-by-event programs for specific action to be taken if a fire situation is detected in the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost even if system primary and secondary power failure occurs. The CPU shall also provide a real time clock for time annotation on the display and remote optional printer.

I. Operator Display:

1. The operator display shall provide controls and indicators used by the system operator. The display shall contain, and display as needed, custom alphanumeric message for all intelligent detectors and addressable modules. Such message information shall be stored in programmable non-volatile memory.
2. The display board shall provide an 80-character alphanumeric Liquid Crystal Display (LCD). It shall also 24 LEDs for system indication such as AC POWER; SYSTEM ALARM; SYSTEM TROUBLE; ACKNOWLEDGE; SIGNAL SILENCE, etc.

3. Factory programmable system indications and keys shall be available for unique functions. Keys shall be referred to as “Hot Keys”.
4. The Display Interface shall provide a 15-key touch keypad with control capability to command all system functions, and entry of any numeric information. The keypad shall include means to enter a minimum of two different passwords to prevent unauthorized manual control.
5. Ground fault indication shall be displayed on a system and initiating zone basis.

J. Communications Ports:

1. The system shall provide the following interfaces:
 - a. One port for remote annunciator command center.
 - b. One port for central station communication.
 - c. One port for service and field programming.
 - d. One port for Printer.

K. Mechanical Design:

1. The Fire Alarm Control Panel (FACP) shall be housed in a cabinet designed for mounting recessed or directly to a wall or vertical surface. The back box and door shall be constructed with provisions for electrical conduit connections. The door shall provide a key lock and shall include an opening for viewing.
2. The FACP shall be modular in structure for ease of installation and maintenance.

L. One Person Test Feature: The control unit shall include a special one-person test feature, which will allow a single person to test all initiating devices and indicating appliance in a system without returning to the panel to reset the system. A special password shall be required to enter the test mode. The service-technician shall be able to re-select the initiating and indicating circuits that are to be included in the one-person test mode. The Walk-Test shall include a special audible indication that a trouble has been detected on an analog device, for the service-technician to check proper system wiring.

M. Provide addressable monitor modules to interface manual FACP to stations and other non-addressable detection components as required. The modules shall be capable of being mounted in a 4 x 4 x 2 1/8 inch (100 x 100 x 54 mm) junction box.

N. Provide addressable control modules to interface FACP to fire alarm reporting panel, audible and visual devices and other control components as required. The modules shall be capable of being mounted in a 4 x 4 x 2 1/8 inch (100 x 100 x 54 mm) junction box.

O. Fire-Alarm Initiating Devices:

1. Addressable Devices: All addressable detectors shall:
 - a. Provide a test means whereby they will simulate an alarm condition and report that condition to the FACP. Such a test may be initiated at the detector itself, by activating a magnetic switch, or may be activated remotely on command from the control panel.
 - b. Provide address-setting means on the detector head using switches. The detectors shall also store an internal identifying code which the FACP shall use to identify the type of detector.
 - c. Provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. Both LEDs may be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect an external remote alarm LED.
2. Addressable pull stations shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Operated stations shall have a positive, visual indication of operation and utilize a key type reset. Manual stations shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inch (45 mm) or larger. Mount stations inside a red, weatherproof enclosure with a clear polycarbonate hinged front cover where station is indicated on the drawings as NEMA 4, NEMA 4X and hazardous areas including Class I, Division 1 and 2.
3. Analog/Addressable Area Photoelectric Smoke Detectors: Photoelectric Smoke Detectors shall use the photoelectric principle to measure smoke density and shall, on command from the control panel send data to the panel representing the analog level of smoke density. These addressable detectors shall connect with two wires to one of the control addressable input circuits.
4. Analog/Addressable Thermal Detectors: Thermal detectors shall use an electronic sensor to respond to temperatures exceeding 135 degrees F (57 degrees C) or 190 degrees F (88 degrees C) as noted on the plans. Sensing elements shall be replaced without removing the detector base. The detector shall, on command from the control panel, send data to the panel representing the analog temperature level. These addressable detectors shall connect with two wires to one of the control addressable input circuits.
5. Each detector shall be provided with a steel mounting plate, and the entire unit shall mount on a double gang electrical box.

6. Analog/Addressable Duct Smoke Detectors: Provided under Section 23 00 00.
 - a. The detectors shall, on command from the control panel, send data to the panel representing the analog level of smoke intensity.
7. Provide devices suitable for the area classifications as indicated on the Contract Drawings (i.e., NEMA 1, NEMA 4, NEMA 4X, and NEMA 7 (Class I, Division 1 or 2) NEMA 4X, etc).

P. Fire Alarm Indicating Devices:

1. Visual appliances shall be installed as shown on the drawings in accordance with the requirements of the UL 1971 standard and NFPA 72. Where multiple visual signals are visible from any location, circuitry shall be incorporated for the synchronization of the flash rate.
 - a. UL 1971 Listed for Emergency Devices for Hearing Impaired in all public mode installations.
 - b. Strobes shall meet UL 1971 flash rate.
 - c. Visual signals shall incorporate a Xenon flashtube enclosed in a rugged Lexan lens or equivalent with solid state circuitry.
 - d. The strobe intensity shall be rated per UL 1971.
 - e. The strobes shall be available for semi-flush or surface mounting and in conjunction with audible signals as required.
2. Audible Devices: Audible evacuation signals shall be provided meeting the following requirements:
 - a. Audible Notification appliance shall be electronic and use solid state components.
 - b. Each electronic signal shall provide four field selectable alarm tones. The tones shall consist of: slow hoop, continuous, temporal or interrupted.
 - c. The device shall provide UL dBA measurement at 10 feet (3 m) shall be a minimum of 85 dBA at 10 feet (3 m) for separately mounted audible signals.
 - d. The device shall have provisions for standard reverse polarity type supervision and in/out field wiring using terminals that accept 14 AWG wiring.
 - e. Combination audiovisual alarm horns shall have a high intensity flashing light and alarm horn as an integral unit. Both audio and visual components shall operate from the 24 volt dc polarized indicating circuits. The horn

assembly shall be housed in a rugged, die-cast enclosure, and the electronic light source shall be sealed in silicone and protected by a Lexan lens. The word FIRE shall appear on the lens. Audiovisual alarm devices shall meet the requirements of visual appliances and alarm horns above. Single and/or dual projectors shall be supplied as shown on the plans.

3. Fire Alarm Speakers:

- a. Provide fire alarm speakers conforming to UL 464 having a minimum of three tap settings and separate terminations for each in and out connection. Tap settings shall include taps of 1/4, 1/2 and 1 watt. Speakers shall utilize the 1/2 watt tap in the system. Speakers shall have an output rating of 84 dBA at 10 feet (3 m) as determined by the reverberant room test; data on peak output as determined in an anechoic chamber is not suitable. Speakers shall be capable of installation on standard 4 inch (100 mm) square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single wall mounted unit.
- b. Provide speaker mounting plates equipped with mounting holes and other opening as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.

Q. Power Supply:

1. The power supply for the FACP and fire alarm peripherals shall be integral to the FACP. The power supply shall provide FACP and peripheral power needs.
2. Positive-temperature-coefficient thermistors, circuit breakers, or other over-current protection shall be provided on all power outputs.
3. Input power shall be 120 VAC, 60 Hertz. The power supply shall provide internal batteries and charger. Internal battery capacity shall be sized as required to meet system requirements.
4. The main power supply shall provide a battery charging circuit consisting of a fully automatic standby battery charger, rate compensated, capable of maintaining battery in fully charged state and be capable of recharging batteries to 70 percent of alarm capacity within 12 hours. Provide for normal operation of entire system for 24 hours with power remaining to sound alarms for 5 minutes. For remote stations, provide battery capacity to operate for 60 hours followed by 5 minutes of alarm in accordance with NFPA 72B. Alarm control panels for automatic release of pre-action or deluge sprinkler systems are required to have 90 hours of secondary power followed by 10 minutes of release power and alarm operations.
5. Provide charger with the following supervised functions: circuit protection for shorts, open, disconnected or reversed polarity battery connection, supervision or

protection of high or low voltage, overcharging and charger failure. Automatic load shedding or battery disconnect on deep discharge to prevent battery damage.

6. Batteries shall be 24 volt, rechargeable, gelled electrolyte, totally sealed, fully charged with all interconnections ready for service, maintenance free, long-life.

R. Wiring within Cabinets, Enclosures, Boxes, Junction Boxes, and Fittings:

1. Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet.
2. Conductors which are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box shall be connected to terminal blocks.
3. Mark each terminal in accordance with the wiring diagrams of the system.
4. Make connections with approved pressure type terminal blocks, which are securely mounted.
5. The use of wire nuts or similar devices shall be prohibited.

S. Terminal Cabinets:

1. Provide a terminal cabinet at the base of any circuit riser, and where indicated on the drawings.
2. Terminal size shall be appropriate for the size of the wiring to be connected.
3. Conductor terminations shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the terminal cabinet.
4. Minimum size is 8 inch (200 mm) high by 8 inch (200 mm).

T. Alarm Wiring:

1. Signaling line circuits and initiating device circuit field wiring shall be copper, 18 AWG size conductors at a minimum.
2. Notification appliance circuit conductors, that contain audible alarm devices, shall be solid copper 14 AWG size conductors at a minimum.
3. Where a voice evacuation system is specified, speaker circuits shall be copper 16 AWG size conductors at a minimum.
4. Wire size shall be sufficient to prevent voltage drop problems.

5. Power wiring, operating at 120 VAC minimum shall be 12 AWG solid copper having similar insulation.
6. Provide all wiring in rigid metal conduit, minimum 3/4".

U. Conductor Terminations:

1. Labeling of conductors at terminal blocks in terminal cabinets, FACP, and remote fire alarm control units shall be provided at each conductor connection.
2. Each conductor or cable shall have a shrink-wrap label to provide a unique and specific designation.
3. Each terminal cabinet, FACP, and fire alarm control unit shall contain a laminated drawing which indicates each conductor, its label, circuit, and terminal.
4. The laminated drawing shall be neat, using 12 point lettering minimum size, and mounted within each cabinet, panel, or unit so that it does not interfere with the wiring or terminals.
5. Maintain existing color code scheme where connecting to existing equipment.

V. Wiring to Station Fire Alarm Circuit:

1. Wiring from the master fire alarm box to the fire department monitoring station fire alarm circuit shall be a two-conductor 10 AWG type UF cable in conduit.

W. Remote Annunciator Command Center:

1. The remote Annunciator Command Center (ACC) shall be an 80 (4 x 20) character back-lit LCD type capable of displaying up to 3200 point messages. The remote annunciator shall have the capability of driving up to 576 LEDs for future graphic notification. They shall be sixteen switch inputs that can be used for various system functions; lamp test, trouble silence, general alarm, scroll, system reset, network reset, etc. All fire-alarm controls shall be operational from the Annunciator Command Center.
2. The ACC shall have non-volatile memory. Annunciators which rely on the FACP for memory will not be accepted.
3. The ACC shall be surface mounted with switches located with a locked panel, and easily visible through a glass or plastic viewing plate. Panel door shall have a keyed lock identical to the lock on the fire alarm control panel (FACP).

X. Cellular Dialer:

1. Provide a cellular dialer for communication to central monitoring system. Provide City approved cellular dialer.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install fire alarm system as indicated on the drawings, in accordance with the manufacturer's diagrams and printed instructions, except where otherwise indicated.
1. Wiring: Wiring for systems shall be installed in conduit. Reuse existing fire alarm conduit system where applicable; otherwise, provide conduit as specified in Section 26 05 33 "Raceway and Boxes for Electrical Systems".
 2. Station loops shall be arranged to permit disconnecting and bypassing the system at the base of each riser. External wiring between the control panel and the stations and horns/lights shall connect to terminal strips in accessible locked cabinets. Connections to the terminal strips shall be made with terminal spade lugs or with approved type terminal blocks. Terminal cabinets shall be installed at each point where a station circuit riser originates or any point along a circuit where a tap is made. The conductors for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. The sum of the cross-sectional areas of individual conductors shall not exceed 40 percent of the interior cross-sectional area of the conduit. Gutter space to accommodate all necessary wiring shall be provided.
 3. Panels: Panel enclosures shall comply with the requirements of UL 864. Enclosures having doors over 48 inch (1200 mm) in height shall be provided with a three-point catch and lock; all other doors shall contain a cabinet type cylinder lock. Inserts shall be blind fastened so that no screws show on the panel front.
 4. Detectors: Detectors shall be installed in accordance with manufacturer's printed instructions.
 5. Provide complete wiring and conduit between all equipment. Devices shall be mounted upon UL listed boxes. Wiring splices and transposing or changing of colors will not be permitted.
 6. Junction boxes shall be painted red and labeled as "Fire Alarm System" with decal or approved markings.
 7. Fire Alarm control systems and equipment shall be connected to separate dedicated branch circuits, sized as required for proper service. Circuits shall be labeled "FIRE ALARM."
 8. Review the design drawings and perform a walk-through of all areas with the AHJ.

3.02 PERMITS AND CERTIFICATIONS:

- A. Obtain required local permits.

1. Provide UL certification of the installation.

3.03 FIELD TESTING:

- A. Notify the AHJ and the Owner 30 days before the performance and acceptance tests are to be conducted. The tests shall be performed in the presence of the Owner or his authorized representative. Furnish instruments and personnel required for the tests. Perform an acceptance test on 100% of the system as described in the checklist in Table 1 of FM Global Property Loss Prevention Data Sheet 5-40, Fire Alarm Systems. Tests shall be conducted for the following:
 1. Verify that the system is free of grounds or open circuits. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. The FACP shall indicate when a ground or open circuit exists.
 2. Alarm initiating devices shall be observed and logged for correct zone and sensitivity. These devices and their bases shall be tagged with adhesive tags located in an area not visible when installed, showing the initials of the installing technician and date.
 3. Verify that all strobes, audible devices, pull stations, transmitters, automatic detectors and supervisory devices are functioning as specified.
 - a. Strobes shall deliver the correct foot-candle. Audible devices shall deliver the correct sound pressure levels decibels of the specified device.
 - b. Stations shall close the circuits specified and deliver specified alarm codes. Verify central station receives alarm.
 - c. Automatic detectors shall actuate the specified zones when the appropriate fire or smoke conditions are generated. The detectors shall be exposed to actual smoke used to simulate this test on each and every smoke detector as located in the building; no other test will be accepted.
 - d. Panels and supervisory devices shall display and control functions as specified. Loss of AC system power shall also be tested.
 - e. Close each sprinkler system valve and verify proper supervisory alarm.
 - f. Verify activation of all water flow switches.
- B. System tests to be performed under the supervision of a qualified representative and the AHJ.
- C. Perform all tests to verify the correction of defects found in the initial testing. If testing identifies system modifications are required to accomplish the required operation, perform work at no additional cost to the Owner and retest the system.

D. Furnish training as follows:

1. Training in the receipt, handling and acknowledgment of alarms.
2. Training in the system operation including manual control of output functions from the system control panel.
3. Training in the testing of the system.

3.04 CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 31 05 19.13

GEOTEXTILES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide geotextile indicated or in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Association of State Highway and Transportation Officials (AASHTO):

- 1. M288: Standard Specification for Geotextile Specification for Highway Applications.

- B. ASTM International (ASTM):

- 1. D4355: Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
- 2. D4491: Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
- 3. D4533: Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
- 4. D4632: Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
- 5. D4751: Standard Test Method for Determining Apparent Opening Size of a Geotextile.
- 6. D6241: Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.03 DEFINITIONS:

- A. Minimum Average Roll Value (MARV): All property values, with the exception of apparent opening size (AOS), represent minimum average roll values in the weakest principal direction. MARV listings for AOS represent the maximum average roll value.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Manufacturer Certificates.

2. Manufacturer Installation Instructions and Details.

3. Manufacturer Catalog Data.

1.05 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

A. Comply with the requirements specified in Section 01 66 10.

B. Label each roll of geotextile fabric with geotextile manufacturer, product width, length, and package weight, number, or symbol to identify production run.

C. Wrap fabric in a heavy-duty protective covering until it is ready for installation. Recover previously opened rolls with a waterproof cover.

D. Protect the fabric from direct sunlight, ultraviolet rays, temperatures greater than 140 degrees F, mud, dirt, dust, and debris at all times during shipment and storage.

E. Store fabric on clean, dry surfaces, free of foreign substances such as grease, oil, paint, epoxy, cement, or any other substances which would have a deleterious effect on the fabric.

F. Elevate fabric a minimum of 12 inches above ground level when stored outside.

G. Do not use hooks, tongs, or other sharp tools and instruments when handling fabric.

H. Unload or handle fabric in one of the following ways:

1. By placing slings under the rolls.

2. By using a pole inserted through a hollow core, provided the pole extends 1-foot minimum beyond each end of the core and lifting and handling devices are attached to only that portion of the pole located outside the ends of the core.

3. By hand.

PART 2 - PRODUCTS

2.02 SILT FENCE GEOTEXTILE:

A. Conforming to AASHTO M288.

B. Service requirements Table 31 05 19.13-1

Table 31 05 19.13-1			
Woven Property	Test Method	Units	Value (MARV)
Grab Strength (minimum)	ASTM D4632	lbs	100
Permittivity (maximum)	ASTM D4491	sec ⁻¹	0.10
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve No.	20-30
Ultraviolet Stability (minimum)	ASTM D4355	Percent	70

C. Manufacturers or approved equal:

1. Geotex 2130 as manufactured by Propex.
2. Baltech 940 by Belton Industries
3. W100 by SKAPS Industries

2.03 SEPARATION GEOTEXTILE:

- A. Physical Requirements: AASHTO M288.
- B. Class 2 fabric according to AASHTO M288.
- C. Service Requirements Table 31 05 19.13-2

Table 31 05 19.13-2			
Non-Woven Property	Test Method	Units	Value (MARV)
Grab Strength	ASTM D4632	lbs	160
Elongation	ASTM D4632	Percent	50
Trapezoidal Tear Strength	ASTM D4533	lbs	60
CBR Puncture Strength	ASTM D6241	lbs	410
Permittivity	ASTM D4491	sec ⁻¹	1.5
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve No.	70
Ultraviolet Stability	ASTM D4355	Percent	70

D. Manufacturers or approved equal:

1. Mirafi 160N as manufactured by TenCate Geosynthetics
2. 160NW by US Fabrics
3. Geotex 601 by Propex Geosolutions

2.04 PERFORMANCE/DESIGN CRITERIA:

- A. The average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the MARV.
- B. Erosion Control Silt Fence: Woven, Table 31 05 19.13-1.
- C. Metal Geotextile Pins:
 - 1. Diameter: 3/16 inch, minimum.
 - 2. Length: 18 inches], minimum.
 - 3. Shape: Pointed at one end with head on other end for retaining washer.
 - 4. Washer: Steel, with minimum outside diameter of 1-1/2 inches.
- D. Wire Staples: 8 gage (4.3 mm) minimum.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Place geotextile on areas that are smooth and free of projections or depressions.
 - 1. Do not drag the geotextile across the subgrade.
 - 2. Roll geotextile out as smoothly as possible in the direction of vehicle travel.
- B. Do not operate construction equipment or traffic directly on geotextile.
- C. Cover the geotextile with indicated cover material as soon as possible when placed for construction.
 - 1. Do not leave uncovered for more than five days.
- D. Place cover material on the geotextile in a manner that the geotextile is not torn, punctured, or shifted.
 - 1. Use at least a 6-inch-thick cover layer or twice the maximum aggregate size, whichever is thicker.
 - 2. Do not end-dump cover material directly on the geotextile except as a starter course.
- E. Limit construction vehicles in size and mass so rutting in the initial layer above the geotextile is not more than 3 inches deep or half the layer thickness, whichever is less.
 - 1. Do not turn vehicles on the first layer.

- F. Install geotextile fabric in accordance with manufacturer's printed instructions.
- 3.02 INSTALL SILT FENCE GEOTEXTILE:
- A. Conforming to AASHTO D6462.
- 3.03 INSTALL SEPARATION GEOTEXTILE:
- A. Install for pavement sections or other applications at locations shown.
 - B. Overlap the geotextile at least 2 feet at all longitudinal and transverse joints or sew the geotextile unless otherwise specified.
 - C. Repair: Place patch over damaged area and extend 3 feet beyond the perimeter of the tear or damage.
 - D. Place fill, beginning with the sheets overlapped, above subsequent sheets to hold geotextile in place.
 - E. Use pins 18 inches long to help secure the geotextile during installation.
- 3.04 INSTALLATION – TRENCHES:
- A. Install in accordance with AASHTO M288, Appendices A1 and A3 except as modified below.
 - B. Place filter fabric in the manner and at the locations indicated. Do not use fabric with defects, rips, holes, flaws, deterioration, or damage of any nature.
 - C. Handle and place filter fabric in accordance with the manufacturer's recommendations. Stretch, align, and place the fabric in a wrinkle-free manner.
 - D. Place fabric with the long dimension parallel to the centerline of the trench and lay smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 18 inches of overlap for each joint.
 - E. Insert securing pins with washers through both strips of overlapped fabric at intervals not greater than 5 feet, along a line through the midpoint of the overlap.
 - F. Install additional pins regardless of location to prevent any slippage of the filter fabric. Place the fabric so that the upstream strip of fabric will overlap the downstream strip. Push each securing pin through the fabric until the washer bears against the fabric and secures it firmly to the foundation.
- 3.05 REPAIR/RESTORATION:
- A. Protect the fabric at all times during construction from contamination by surface runoff. Remove and replace fabric so contaminated with uncontaminated fabric. Repair any

damage to the fabric during its installation or during placement of crushed rock or bedding materials.

- B. Repair fabric damaged during placing, in other than underdrain piping service, by placing a piece of fabric large enough to cover the torn or punctured area, meet the overlap requirement, and extend a minimum of 12 inches beyond the edge of the damaged area.
- C. Replace fabric that has become damaged from vehicular traffic, equipment, or repetitive operations.

3.06 SEWING:

- A. Perform sewing as specified in AASHTO M288, Appendix, Seaming.

3.07 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 31 10 00

SITE CLEARING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide site clearing as indicated and in compliance with Contract Documents.
- B. Section Includes:
 - 1. Clearing and grubbing.
 - 2. Tree and shrub protection and removal.
 - 3. Removal of debris related to clearing and grubbing operations.

1.02 DEFINITIONS:

- A. Caliper: Instrument used to measure tree diameter.
- B. Clearing: Removal and disposal of above-ground items defined herein.
- C. Grubbing: Removal and disposal of below-ground items defined herein.

1.03 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 - 1. Permits
 - a. Copy of Land Disturbance Permit
 - 2. Certificates
 - a. Copy of herbicide label bearing EPA registration number.
 - b. Copy of Arborist Certification

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Permits:
 - 1. The Contractor shall be responsible for obtaining required permits and complying with all City, State, and Federal storm water management regulations and requirements, including preparing and implementing a Storm Water Pollution

Prevention Plan (SWPPP) for Construction Activities. The Contractor shall submit a copy of the Notice of Intent and the SWPPP to the Owner for review and approval.

C. Certifications:

1. Certified Arborist: All tree pruning, tree repair, and tree removal shall be performed by competent workers, under the supervision of an arborist holding certification from the International Society of Arboriculture (ISA) or equivalent education and experience.

1.05 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Herbicide: Comply with Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) – Title 7 U.S.C. Section 136. Submit copy of herbicide label, bearing EPA registration number.

1.06 SITE CONDITIONS:

- A. Existing facilities, structures, and utilities are shown in accordance with available surveys and records. The indicated locations of underground utilities and structures are approximate. Other utilities may exist which are not indicated.

PART 2 - PRODUCTS

2.01 ACCESSORIES:

- A. Herbicide: Registered EPA Pesticide.
- B. Tree Wound Paint: Bituminous based paint formulated for tree wounds.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify survey benchmarks and intended elevations for the Work are as indicated.
- B. Verify temporary erosion and sediment control measures are installed before commencing with any other work at the site.
- C. Prior to any excavation in the vicinity of any existing underground facilities, including all water, sewer, storm drain, gas, petroleum products, or other pipelines; all buried electric power, communications, or television cables; all traffic signal and street lighting facilities; and all roadway and state highway rights-of-way, the Contractor shall notify the regional notification center (Blue Stakes of Utah) at 1-800-662-4111 or 811 or submit an on-line

request at www.bluestakes.org at least 3 days, but no more than 7 days, prior to such excavation.

- D. Contact utility companies and authorities to make arrangements for handling and disposal of utilities encountered during construction.

3.02 PREPARATION:

- A. Protect benchmarks, survey control points, and existing structures to remain from damage or displacement.
- B. Protect trees and vegetation to remain. Do not cut or injure trees and vegetation outside easement lines and outside designated clearing areas.
- C. Protect all underground utilities and structures that are to remain. If damage occurs, immediately notify the utility owner within the hour.
- D. Protect site features to remain from damage by construction equipment and vehicular traffic.
- E. Identify waste and salvage areas for stockpiling of removed materials.

3.03 RESTORATION:

- A. Existing surfaces, features, utilities, or structures that are to remain but are damaged during construction shall be restored to at least the condition in which they were found immediately before work began, unless noted otherwise.
- B. Restore damaged utilities to the satisfaction of the utility owner.
- C. Restore damaged private property to the satisfaction of the property owner.

3.04 CLEARING:

- A. Remove and dispose of off-site:
 - 1. Trees, snags, brush, shrubs, downed timber, decayed wood, and other vegetative growth.
 - 2. Rocks, tiles, lumps of concrete, trash piles, debris, refuse, and rubbish. Remove all evidence of their presence from the surface.
- B. Clear ground within limits of work and width of permanent easement, unless otherwise noted.
- C. Manual cutting of trees, stumps, and stubs during clearing shall be as close to ground surface as practicable but no higher than 6-inches above ground for small trees (8-inches or less), and not higher than 12 inches above ground for larger trees (greater than 8-inches).

- D. Obey all federal, state, and local regulations and guidance regarding the cutting, burning, and disposal of diseased trees and vegetation.

3.05 GRUBBING:

- A. Remove and dispose of all stumps, buried logs, matted roots, roots larger than 2 inches, and organic materials off site.
- B. Roots larger than 2 inches in diameter shall be removed to a depth of 12 inches, and roots larger than 1/2-inches in diameter to a depth of 6 inches .
- C. Areas designated to receive pavement or structures shall be grubbed a depth of 18 inches. Measure depths of cut from existing ground surface or proposed finished grade, whichever is lower.
- D. Apply herbicide to remaining roots and vegetation to inhibit growth.
- E. Depressions made by grubbing shall be filled with suitable material and compacted to conform to original adjacent grade.
- F. Do not grub areas within drip line of trees to remain to avoid damage to roots.

3.06 TREE AND SHRUB REMOVAL:

- A. Remove trees and shrubs within permanent and temporary easement by felling or cutting individual vegetation and grubbing. The Contractor may dispose of the material at the Provo City composting facility located at 1625 S Industrial Parkway.

3.07 TREE AND SHRUB PROTECTION:

- A. Protect and prune indicated designated trees and shrubs within the clearing limits.

3.08 PRUNING:

- A. Trim dead branches 1-1/2-inches or more in diameter and branches to heights and in a manner as indicated. Neatly cut limbs and branches close to the bole of the tree or main branches. Paint cuts more than 1-1/4-inches in diameter tree wound paint.

3.09 BURNING:

- A. Burning is not permitted on site.

3.10 CLEANING:

- A. Promptly dispose of excess and unsuitable material off site.
- B. Remove debris, junk, and trash from site.
- C. Leave site in clean condition, ready for subsequent work.

- D. Clean up spillage and wind-blown debris before entering public or private property, adjacent to site.

3.11 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 31 22 00

GRADING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide grading as indicated and in compliance with Contract Documents.
- B. Section Includes:
 - 1. Rough grading.
 - 2. Finish grading.
 - 3. Stockpiling of topsoil and subsoil.
 - 4. Disposal of unsuitable and excess materials.

1.02 DEFINITIONS:

- A. Unsuitable Material: Defined in Section 31 23 00.
- B. Foundation Influence Zone (under foundations, pavements, or sidewalks): Area below base bounded by 1H:1V slope extending outward from 1 foot beyond outer edges.
- C. Utility Influence Zone (around piping or ducts): Area below with limits bounded by perpendicular line, 6 inches below pipe or duct with a 1H:1V slope extending outward from that line, from 1 foot beyond the edge of pipe or duct.

1.03 SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.05 SITE CONDITIONS:

- A. Existing Conditions:
 - 1. See Section 01 14 14 for additional requirements.
 - 2. Existing facilities, structures, and utilities are shown in accordance with available surveys and records. The indicated locations of underground utilities and structures are approximate. Other utilities may exist which are not indicated.

3. Prior to any excavation in the vicinity of any existing underground facilities, including all water, sewer, storm drain, gas, petroleum products, or other pipelines; all buried electric power, communications, or television cables; all traffic signal and street lighting facilities; and all roadway and state highway rights-of-way, the Contractor shall notify the regional notification center (Blue Stakes of Utah) at 1-800-662-4111 or 811 or submit an on-line request at www.bluestakes.org at least 2 days, but no more than 7 days, prior to such excavation.
- B. Geotechnical Report, Attachment A: The report is attached for information only. Logs of borings are included in the report and indicate conditions encountered only at test boring locations. Nothing in the contract documents shall be construed as guarantee that other materials will not be encountered or that proportion of materials will not vary from proportions shown on the logs of test borings.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify survey benchmarks and intended elevations for the work are as indicated.
- B. Verify temporary erosion and sediment control measures are installed before commencing with any other work at the site.
- C. Immediately notify the Engineer if suspected hazardous materials are encountered and cease operations in that area.
- D. Identify areas loosened by frost action, softened by flooding or weather, or containing unsuitable material.

3.02 PREPARATION:

- A. Remove material loosened by frost action, softened by flooding or weather, or containing unsuitable material. Replace and compact to same requirements as for specified fill in Section 31 23 00.
- B. Identify required lines, levels, grades, and datum.
- C. Stake and flag locations of known utilities.
- D. Locate, identify, and protect from damage all above- and below-ground utilities to remain.
- E. Notify utility owner prior to removal or relocation of utility. See Sections 01 11 00 and Section 01 50 00 for notification requirements.

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- F. When necessary to excavate through roots of trees or vegetation to remain – perform work by hand and cut roots with sharp axe.

3.03 ROUGH GRADING:

A. Topsoil removal and stockpiling:

1. Strip topsoil from areas that are to be excavated, landscaped, or graded.
2. Separate organic matter (e.g., root zones) from topsoil. Dispose of organic material off site.
3. Do not strip topsoil while wet.
4. Stockpile excavated topsoil on site. Do not mix topsoil with foreign materials.

B. Subsoil removal and stockpiling:

1. Remove subsoil from areas that are to be excavated, landscaped, or graded.
2. Do not remove wet subsoil unless it is subsequently processed to obtain optimum moisture content.
3. Stockpile suitable subsoil on-site.

C. Provide for free drainage of construction site.

D. Benching Slopes: Horizontally bench existing slopes greater than 4H:1V to key fill material to slope for firm bearing.

E. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill in Section 31 23 00.

F. Disc level surfaces.

G. Rough grade site to achieve lines and grades indicated with allowances for imported fill thicknesses.

H. Provide positive drainage away from buildings and structures by sloping a minimum of 2 inches over 10 feet in paved areas or 5 inches over 10 feet in unpaved areas.

3.04 FINISH GRADING:

A. Before finish grading:

1. Verify subgrade is contoured and compacted.
2. Verify backfill has been inspected.

- B. Fine grade to eliminate uneven areas and depressions. Follow profiles and contours of subgrade and bring to finish grade as indicated.

3.05 STOCKPILING:

- A. Location: As indicated or directed. Do not locate stockpiles over existing or new utilities unless directed.
- B. Height: 8 feet maximum.
- C. Slope: 2H:1V, maximum
- D. Drainage: Grade to prevent standing water.
- E. Provide erosion and sediment control around downhill-side of stockpile perimeter.
- F. Immediately stabilize dormant stockpiles within 7 days. Stockpiles and portions of stockpiles that will not be actively used for at least 30 days shall be considered dormant.

3.06 EXCESS MATERIAL:

- A. Excess grading material, suitable for backfilling or site grading, that is not necessary to complete the work at the project site shall be properly removed and disposed by Contractor.
- B. Dispose offsite any unsuitable materials and excess materials not received by Owner.

3.07 TOLERANCES:

- A. Subgrade:
 - 1. Elevation: 2 inches, from required elevation.
 - 2. Grade: 1 inch per 10 feet.
- B. Finish Grade:
 - 1. Elevation: 1/2 inch, from required elevation.

3.08 FIELD QUALITY CONTROL:

- A. See Section 31 23 00 for compaction and testing requirements.

3.09 CLEANING:

- A. See Sections 01 14 14 and 01 74 23 for additional requirements.
- B. Remove unused stockpiles, grade area to prevent standing water, protect from erosion, and stabilize.

- C. Leave site clean and raked, ready to receive landscaping.

3.10 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.
- B. Submit existing utility location information as part of record drawings. Include ticket numbers and original information from utility owners.

END OF SECTION

SECTION 31 23 00

EXCAVATION AND FILL

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide excavation and fill as indicated and in compliance with Contract Documents.
- B. Section includes:
 - 1. Excavation and fill for: Foundations, structures, and pavement; site drainage, structures, and features.
 - 2. Below-grade utilities within building footprints. (Refer to Section 31 23 23 for all other utility trenching and backfill).
 - 3. Embankments.
 - 4. Dewatering excavations.
 - 5. Controlled fill using materials from imported and on-site sources.
 - 6. Soil and aggregate materials.
 - 7. Compaction and testing.

1.02 REFERENCES:

- A. American Association of State and Highway Transportation Officials (AASHTO):
 - 1. M147: Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses.
- B. ASTM International (ASTM):
 - 1. C33: Specification for Concrete Aggregates.
 - 2. C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
 - 3. D421: Practice for Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants.
 - 4. D422: Test Method for Particle-Size Analysis of Soils.
 - 5. D698: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³)).

6. D1556: Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
7. D1557: Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft³ (600 kN-m/m³)).
8. D2167: Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
9. D2487: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
10. D2940: Standard Specification for Graded Aggregate Material For Bases or Subbases for Highways or Airports.
11. D4318: Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
12. D6938: Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

C. Occupational Safety and Health Administration (OSHA) Standards and Regulations:

1. 29 CFR 1926, Subpart P: Safety and Health Regulations for Construction, Excavations.

1.03 DEFINITIONS

- A. Percent Compaction or Compaction Density: The field dry density of compacted material, expressed as a percentage of the maximum dry density.
- B. Field Dry Density or Field Density: In-place density as determined by ASTM D1556 (Sand Cone Method), ASTM D2167 (Rubber Balloon Method), or ASTM D6938 (Nuclear Method).
- C. Maximum Dry Density: Laboratory density as determined by ASTM D698 (Standard Proctor) or ASTM D1557 (Modified Proctor) and occurring at the optimum moisture content of the material being tested.

1.04 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 1. Temporary excavation and shoring drawings for worker protection in accordance with the General Conditions.
 2. Gradation analysis.
 3. Dewatering plan including disposition of groundwater.

4. Materials Sources: Name of source, location, date of sample, sieve analysis, and laboratory compaction characteristics.
5. Test and Evaluation Reports:
 - a. Field density testing reports: Provide results from field density testing of prepared subgrade and compacted fill.
 - b. Grain-size analysis.
 - c. Laboratory compaction characteristics of soils.
 - d. Water content.
6. Geotextile:
 - a. At least two weeks prior to shipment, submit manufacturer's certificate of compliance and physical property data sheet indicating that requirements for materials and manufacture are in conformance as specified.
 - b. For informational purposes only, submit manufacturer's printed installation instructions.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Testing will be provided by the Owner as specified. Contractor shall be responsible for cost of testing and inspection conducted as a result of non-conforming work.
- C. Protect excavations by shoring, bracing, sheet piling, underpinning or other methods required to prevent cave-in of loose soil. Protection shall be in accordance with OSHA 29 CFR 1926, Subpart P.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Geotextile Fabric:
 1. Provide rolls wrapped with protective covering to protect from mud, dirt, dust, and debris. Label each roll with number or symbol to identify production run.
 2. Protect from sunlight during transportation and storage. Do not leave exposed to sunlight for more than two weeks during installation operations.

1.07 SITE CONDITIONS:

- A. Existing Conditions:

1. Geotechnical Report, Attachment A: The report is attached for information only and is not part of the contract documents. Logs of borings are included in the report and indicate conditions encountered only at test boring locations. Nothing in the contract documents shall be construed as guarantee that other materials will not be encountered or that proportion of materials will not vary from proportions shown on the logs of test borings.

PART 2 - PRODUCTS

2.01 FILL MATERIALS:

- A. Suitable Material: Material from on-site excavation and permitted off-site sources that meets all the specified requirements for its intended use and is not unsuitable. Wet subgrade material which meets other requirements for suitable material is suitable.
- B. Unsuitable Material: Material that fails to meet requirements for suitable materials; or contains any of the following:
 1. Organic clay, organic silt, or peat, as defined in ASTM D2487.
 2. Vegetation, wood, roots, leaves, and organic, degradable material.
 3. Stones or rock fragments over 6 inches in any dimension.
 4. Porous biodegradable matter, excavated pavement, construction debris, rubbish, or refuse.
 5. Ice, snow, frost, or frozen soil particles.
- C. Untreated Base Course: Refer to APWA 2017 Standard Specifications Section 32 11 23 Grade 1-1/2 Untreated Base Course.
- D. Granular Borrow: Refer to APWA 2017 Standard Specifications Section 31 05 13 Common Fill.
- E. Free Draining Granular Backfill: Refer to UDOT 2017 Standard Specifications Section 02056 Embankment, Borrow, and Backfill.
- F. General Fill: Suitable, unclassified material.
- G. Structural Fill: Suitable material, as directed by the Geotechnical Engineer, that is classified by the Unified Soil Classification System (USCS) in accordance with ASTM D2487 as GW, GP, GM, GC, SW, SP, SM, SC. Verify that the largest particles in the fill are no greater in dimension than one-half the thickness of the compacted lift thickness.
- H. Controlled Low-Strength Material (CLSM): Section 03 34 00.
- I. Concrete Fill: Section 03 30 00. Minimum compressive strength, 2,000 psi.

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J. Granular Fill:

1. Densely Graded: ASTM D2940 for base under onsite paving.
2. Open Graded: ASTM C33, coarse aggregate, No. 57

2.02 EQUIPMENT:

- A. Compaction equipment shall be capable of consistently achieving the specified compaction requirements.

2.03 ACCESSORIES:

- A. Geotextile: Section 31 05 19.13.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Verify that dewatering support systems are in place before commencing with excavation.
- B. Verify that excavation safety and support systems meeting the requirements of OSHA 29 CFR 1926, Subpart P are in place before commencing with excavation.
1. Minimum slopes for laying back excavations or materials are contained in OSHA 29 CFR 1926, Subpart P; Appendices A and B.
 2. Minimum requirements for shoring and bracing are contained in OSHA 29 CFR 1926, Subpart P; Appendix C.
- C. Verify that fill materials submittals have been accepted by Engineer before commencing with work requiring the use of these materials.
- D. Verify that erosion and sediment control measures are in place and functioning properly.
- E. Immediately notify the Engineer if unexpected subsurface facilities or suspected hazardous materials are encountered during excavation. Discontinue affected work in area until notified to resume work.
- F. Test Pits:
1. Comply with the requirements in Section 01 14 14.
 2. Excavate test pits to field verify the locations of existing underground utilities at crossings and at tie-in points before ordering materials or commencing excavation. Immediately notify the Engineer if conflicts are encountered.

3.2 PREPARATION:

- A. Underpin adjacent structures that could be damaged by excavation work.
- B. Cut pavement with saw or pneumatic tools to prevent damage to remaining pavement. Dispose of large pieces of demolished pavement before proceeding with excavation.
- C. Remove subsurface structures and related obstructions.
- D. Remove boulders within excavation limits.

3.3 PROTECTION OF IN-PLACE CONDITIONS:

- A. Comply with the requirements specified in Section 01 14 14.
- B. Support and protect from damage – existing pipes, poles, wires, fences, curbs, property line markers, and other features or structures which must be preserved in place to avoid being temporarily or permanently relocated.
- C. Excavation Near Existing Structures:
 - 1. Discontinue digging by machinery when excavation approaches pipes, conduits, or other underground structures. Continue excavation by use of hand tools. Include such manual excavation in work to be done when incidental to normal excavation and under items involving normal excavation.
 - 2. Excavate test pits near, or at intersection with, existing utilities or underground structures to determine the exact location of existing features.
- D. Excavation Near Private Property:
 - 1. Record existing condition of features on adjacent property by means of dated photographs or cameras. Provide construction photographs according to Section 01 32 33.
 - 2. Enclose uncut tree trunks adjacent to work in wooden boxes of such height necessary to protect tree from injury due to piled material, equipment, or operations. Operate excavating machinery and cranes to prevent injury to overhanging branches and limbs.
 - 3. Protect cultivated hedges, shrubs, and plants which would otherwise be damaged by the work.
 - 4. Where protection of vegetation is not possible, dig up, temporarily transplant, and maintain. After active construction operations in the area have ceased, transplant vegetation to the original positions and provide water and nursery care until growth is re-established.

5. Do not use or operate tractors, bulldozers, or other power-operated equipment on paved surfaces. Provide protection on pavement or tracks if construction traffic is unavoidable.

3.4 RESTORATION:

- A. Restore private property and structures promptly. Begin restoration work within 24 hours of when damage occurred.
- B. Existing surfaces, features, or utilities that are to remain but are damaged during construction shall be repaired or replaced to at least the condition in which they were found immediately before work began, unless noted otherwise.
- C. Damaged Trees To Remain: Cut all damaged branches, limbs, and roots smoothly and neatly without splitting or crushing. Neatly trim, cut the injured portions and cover with an application of grafting wax or tree healing paint. Replace damaged trees which subsequently die or continue to show lack of growth due to damage.
- D. Cultivated Vegetation: Includes, but is not limited to, hedges, shrubs, and plants. Vegetation that is damaged shall be replaced with equal kind and of at least the quality before work began.

3.5 EXCAVATION:

- A. Excavate to accommodate new structures and construction operations.
- B. Excavate to lines and grades necessary to provide finish grades.
- C. Excavations that are not shored and deeper than 4 feet shall have banks laid back to a minimum stable slope matching the angle of repose of the excavated material.
- D. Workers shall have an adequate means of exit from excavations that are 4 feet or more in depth. The means of exit shall not require more than 25 feet of lateral travel.
- E. Establish limits of excavation to allow adequate working space for installing forms and for safety of personnel.
- F. Carry out program of excavation, dewatering, and excavation support systems to eliminate possibility of undermining or disturbing foundations of existing structures or the work.
- G. Provide dewatering system in accordance with Section 31 23 19.
- H. Provide sheeting and shoring in accordance with Section 31 50 00.
- I. Preserve material below and beyond the lines of excavations.
- J. Locate stockpiled excavated material at least 3 feet from edge of excavations to prevent cave-ins or bank slides.

- K. Excavate for depressed mat foundations so that adjacent sections of foundation mat will rest on undisturbed ground.

3.6 SUBGRADE PREPARATION:

- A. The exposed surface shall be examined by an engineering geologist or soils engineer to determine that the proper bearing material has been exposed.
- B. Materials which are determined to be unsuitable by visual inspection shall be over-excavated below the foundation subgrade and backfilled with structural fill.
- C. Backfill with compacted open-graded granular fill wrapped with nonwoven geotextile fabric. In no case shall the aggregate be placed directly on the exposed subgrade prior to placing the geotextile fabric.
- D. Compact subgrade and proof roll to identify soft spots or other deficiencies prior to filling operations or placing foundations. Correct deficiencies as specified for AUTHORIZED OVER-EXCAVATION and repeat proof roll procedure until successful.
- E. When subgrade is below controlled fill, scarify subgrade to bond with subsequent material lifts.
- F. Proof roll foundation subgrade prior to filling operation or placing foundation concrete. Continue until successful proof test is attained.

3.7 AUTHORIZED OVER-EXCAVATION:

- A. If proof roll test fails then remove unsuitable material plus an additional 6 inches, and backfill with structural fill.

3.8 UNAUTHORIZED EXCAVATION:

- A. Contractor is responsible for backfilling unauthorized excavations with structural fill.

3.9 FILL:

- A. Fill to lines and grades necessary to provide finish grades.
- B. Use a placement method that does not disturb or damage other work or existing features.
- C. Maintain fill materials within 3 percent of optimum moisture, to attain required compaction density.
- D. Place and compact material in equal continuous layers.
- E. General fill may be used in open areas, over lot fill, and areas which are not load bearing.
- F. Use structural fill beneath and adjacent to buildings and structures, and beneath pavements.

- G. Use concrete fill where footing bearing surfaces are over-excavated or footing is otherwise not bearing on undisturbed soil.
- H. Maximum compacted depth is 6 inches for aggregate materials and 8 inches for soil materials, unless noted otherwise.
- I. Do not backfill against or on hydraulic structures until testing is completed. See Section 03 05 10 for leakage testing requirements of concrete containment structures. Conduct hydraulic testing as soon as practicable after structures are constructed and other necessary work has been done. Start backfilling promptly after completion of tests.
- J. Deposit material evenly around structure to avoid unequal soil pressure.
- K. Do not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking, or other damage.

3.10 COMPACTION:

- A. Compact to density specified and indicated for various types of material. Control moisture content of material being placed as specified, or if not specified - at a level slightly lower than optimum.

Table 31 23 00-2	
Area	Percentage of Maximum Dry Density as defined by ASTM D1557 (Modified Proctor)
Scarified subgrades	90
Under pavement, slabs	95
Under structures or within 25 feet of structures	95
Under exterior concrete slab and sidewalks	95
Open or grassed areas	85
Topsoil	85 (maximum)

3.11 BACKFILLING AGAINST STRUCTURES:

- A. Backfill shall not be placed against foundation walls until all interior floors have been placed and the concrete has attained design strength. This includes the floor level at grade or the next level above grade if no floor is within 2 feet of finished grade.
- B. Backfill shall not be placed against cantilever walls until the concrete has attained design strength.

3.12 EMBANKMENT FILL AND COMPACTION:

- A. Begin filling in lowest section of work area. Grade surface of fill approximately horizontal but provide with sufficient longitudinal and transverse slope to allow for runoff of surface water from every point.
- B. Install temporary dewatering sumps in low areas during filling operation where excessive amounts of rain runoff collect.
- C. Reduce moisture content of fill material, if necessary, in source area by aerating it over during warm and dry atmospheric conditions. A large disc harrow with two to three foot diameter disks may be required for working soil in a drying operation.
- D. Compact uniformly throughout. Keep fill surfaces sufficiently smooth and free from humps and hollows to allow for proper and uniform compaction. Do not permit hauling equipment to follow a single track on the same layer but direct equipment to spread out to prevent over compaction in localized areas. Take care in obtaining thorough compaction at edges of fill.
- E. Slightly slope surface of fill to ensure drainage during periods of wet weather. Do not place fill while rain is falling or after a rain-storm until the Engineer considers conditions satisfactory. During such periods and upon suspension of filling operations for periods in excess of 12 hours, roll smooth the surface of fill using a smooth wheel static roller to prevent excessive absorption of rainfall and surface moisture. Prior to resuming compaction operations, remove muddy material off surface to expose firm, compacted material, as determined by the Engineer.
- F. When fill is placed against an earlier fill or against in-situ material under and around structures, including around piping beneath structures or embankments, slope junction between two sections of fill at 1.5 to 1 (horizontal to vertical). Bench edge of existing fill 24 inches to form a serrated edge of compact stable material against which to place the new fill. Ensure that rolling extends over junction between fills.
- G. Clean debris, remove loose material, and proof roll previously placed fill which has had time to become desiccated or littered with debris.
- H. After spreading each loose lift to the required thickness and adjusting its moisture content, roll with sufficient number of passes to obtain the required compaction. One pass is defined as the required number of successive trips which by means of sufficient overlap will insure complete coverage and uniform compaction of an entire lift. Do not make additional passes until previous pass has been completed.
- I. Fill surface shall be firm and hard when rolled. Reduce moisture content when fill material sinks and weaves under rollers and equipment. Spread out rolling operations over the maximum practicable area to minimize condition of sinking and weaving. Suspend fill operations on portions of embankment where inundations produce surface cracks.
- J. Remove material which fails testing requirements and replace work.

3.13 GEOTEXTILE:

- A. Install geotextile fabric in accordance with manufacturer's printed instructions and Section 31 05 19.13.
- B. Place geotextile fabric on the foundation subgrade prior to placing aggregate material.
- C. Overlap geotextile fabric 18 inches minimum for unsown lap joint. Overlap fabric 6 inches at seam for sewn joint.
- D. Do not permit traffic or construction equipment to travel directly on geotextile fabric.
- E. Place geotextile fabric in relatively smooth condition to prevent tearing or puncturing. Lay geotextile fabric loosely but without wrinkles or creases so that placement of the backfill materials will not stretch or tear geotextile fabric. Leave sufficient slack in geotextile fabric around irregularities to allow for readjustments.
- F. Patch all tears in geotextile fabric by placing additional section of geotextile fabric over tear with a minimum of 3 feet overlay.
- G. Extend the geotextile fabric and wrap around aggregate material along the perimeter of the foundation.

3.14 FIELD QUALITY CONTROL:

- A. See Section 01 43 00 for general requirements for field inspection and testing.
- B. Perform inspection at least once daily to confirm lift thickness and compaction effort for entire fill area.
- C. Perform particle size distribution and gradation analyses using ASTM D422 and following standard practices in ASTM D421. Perform 1 test for every source and submit results to Engineer for acceptance. Repeat the moisture density test for every 5,000 cubic yard of material used.
- D. Perform field density testing in accordance with ASTM D1556, ASTM D2167, or ASTM D6938.
- E. Evaluate field density test results in relation to maximum dry density as determined by testing material in accordance with ASTM D1557 (Modified Proctor).
- F. Perform tests in accordance with ASTM D4318 to determine Liquid Limit, Plastic Limit and Plasticity Index and submit test results to Engineer for acceptance. Minimum of one test per 5,000 cubic yard of soil for use as fill material and whenever classification of material is in doubt as determined by the Engineer.
- G. Location of field density tests shall be as recommended by the Engineer.

- H. In the event compacted material does not meet specified in-place density, re-compact material and re-test area until specified results are obtained.
- I. Frequency of field density tests:

Table 31 23 00-5	
Area	Frequency
Roadways	1 per lift for every 200 linear feet of roadway
Paved Areas	1 per lift for every 3,500 square feet of pavement
Open Areas	1 per lift for each 25,000 square feet of open area
Isolated Footing Perimeter	1 per alternate lift for each 25 linear feet
Footing and Wall Backfill	1 per alternate lift for each 50 linear feet (both sides of wall)
Under Structures	1 per lift for every 1,000 square feet of structure
Around Structures	1 per lift for every 1,500 square feet of structure
Embankment Fills	1 per lift for every 10,000 square feet of embankment
Regardless of the minimum testing frequency specified, field density tests shall be performed by the Contractor in sufficient number for the Contractor's quality control purposes to ensure that specified density is obtained.	

3.15 ADJUSTING:

A. Shrinkage:

1. Build embankments or backfill to a height above finished grade which will, in the opinion of the Engineer, allow for the shrinkage or consolidation of material. Initially, provide at all points, an excess of at least one percent of total height of backfill measured from stripped surface to top of finished surface.
2. Supply specified materials to build up low places when embankment or backfill settles below the finished grade at any time before substantial completion.

3.16 TOLERANCES:

- A. Construct finished surfaces to plus or minus 1 inch of the elevations indicated.
- B. Grade areas of cut and fill to plus or minus 0.20 foot of the grades indicated.
- C. Complete embankment edges to plus or minus 6 inches of the slope lines indicated.
- D. Provide the Engineer with adequate survey information to verify compliance with above tolerances.

3.17 PROTECTION:

- A. Formulate excavation, backfilling, and filling schedule and procedures to eliminate possibility of undermining or disturbing foundations of partially and completed structures, pipelines and embankments or existing structures and pipelines.

3.18 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 31 23 19

DEWATERING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide dewatering as indicated and in compliance with Contract Documents.
- B. Design, furnish, operate, maintain, and remove temporary dewatering systems to control groundwater and surface water to maintain stable, undisturbed subgrades, and permit work to be performed under dry and stable conditions. Work to be done as part of dewatering includes, but is not limited to:
 - 1. Lower the groundwater level.
 - 2. Lower hydrostatic pressure.
 - 3. Prevent surface water from entering the excavation during construction.
 - 4. Implement erosion control measures for disposing of discharge water.
 - 5. Provide and monitor observation wells and geotechnical instrumentation as specified and indicated.
- C. Groundwater within the excavation area shall be lowered to at least 2 feet below the lowest excavation levels as specified and as indicated.
- D. Common dewatering methods include, but are not limited to, sump pumping, deep wells, well points, vacuum well points or combinations thereof.
- E. Common groundwater recharge methods include, but are not limited to, deep wells, large sumps or combination thereof.
- F. The Contractor shall obtain the required permits for discharge from the Contractor's dewatering systems in accordance with 40 CFR Part 122. The discharge location shall be in accordance with permit requirements.

1.02 REFERENCES:

- A. Code of Federal Regulations, Title 40 – Protection of Environment (CFR):
 - 1. 40 CFR Part 122: EPA Administered Permit Programs: The National Pollutant Discharge Elimination System.

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00.

1. Qualification of the Contractor's dewatering specialist's or firm's qualifications a minimum of 4 weeks prior to dewatering work. The submittal shall include, but not be limited to:
 - a. Qualifications of specialist's or firm's Registered Professional Engineer.
 - b. Qualifications of specialist's or firm's field representative who will oversee the installation, operation, and maintenance of the dewatering system.
2. Submit a dewatering plan, and, if applicable, a groundwater recharge plan at least 2 weeks prior to start of dewatering work. Do not submit design calculations. The review will be only for the information of the Owner and third parties for an overall understanding of the project relating to access, maintenance of existing facilities and proper utilization of the site. The Contractor shall remain responsible for the adequacy and safety of the means, methods, and sequencing of construction. The plan shall include the following items as a minimum:
 - a. Dewatering plan and details stamped and signed by a Registered Professional Engineer registered in the state where the project resides.
 - b. Certificate of Design: Refer to Section 01 33 00.
 - c. A list of equipment including, but not limited to, pumps, prime movers, and standby equipment.
 - d. Detailed description of dewatering, maintenance, and system removal procedures.
 - e. Monitoring plan and details, including, but not limited to, number and locations of observation wells and geotechnical instruments such as settlement markers (reference points on structures; minimum of 2 per structure) and piezometers (minimum of 2), and frequency of reading the monitoring devices.
 - f. Erosion and sedimentation control measures, and methods for disposal of pumped water.
 - g. List of all applicable laws, regulations, rules, and codes to which dewatering design conforms.
 - h. List of assumptions made for design of dewatering and for groundwater recharge systems, including but not limited to groundwater levels, soil profile, permeabilities, and duration of pumping and or recharge.

3. Measurement records consisting of observation well groundwater records and the geotechnical instrumentation readings within one day of monitoring.
4. A modified dewatering plan within 24 hours, if open pumping from sumps and ditches results in boils, loss of fines or softening of the ground.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Employ the services of a dewatering specialist or firm having the following qualifications:
 1. Have completed at least 5 successful dewatering projects of equal size and complexity and with equal systems within the last 5 years.
 2. Retain the services of a Registered Professional Engineer (in the state where the project is located) having a minimum of 5 years of experience in the design of well points, deep wells, recharge systems, or equal systems.
 3. Retain the services of a field representative having a minimum of 5 years of experience in installation of well points, deep wells, recharge systems, or equal systems.
- C. If subgrade soils are disturbed or become unstable due to dewatering operation or an inadequate dewatering system, notify the Engineer, stabilize the subgrade, and modify system to perform as specified.
- D. Notify the Engineer immediately if settlement or movement is detected on structures. If the settlement or movement is deemed by the Engineer to be related to the dewatering, take actions to protect the adjacent structures and submit a modified dewatering plan to the Engineer within 24 hours. Implement the modified plan and repair damage incurred to adjacent structures.
- E. Immediately notify the Engineer if oil or other hazardous materials are encountered after dewatering begins.

1.05 HYDRAULIC UPLIFT OF STRUCTURES:

- A. The Contractor shall be responsible for the protection of all structures against hydraulic uplift until such structures have been accepted finally by the Owner.
- B. In this regard, the Contractor is advised that all tanks when completed are designed to resist hydraulic uplift from groundwater up to the elevation indicated on the structural drawings when the structure is completed. The concrete slab bottoms shall be placed in the dry, with the use of wellpoints or other dewatering means to keep the water elevation sufficiently low to carry on the work.
- C. Buildings with basements are not designed to resist hydraulic uplift from groundwater.

1.06 PRECAUTIONS AGAINST HYDROSTATIC UPLIFT DURING CONSTRUCTION:

- A. The Contractor shall maintain a low groundwater elevation in the vicinity of the structures until they are complete. In case of extremely high-water during construction of the structures, it may be necessary to flood the structures to maintain stable conditions.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.08 SITE CONDITIONS:

- A. Subsurface Conditions: Refer to Geotechnical Report. Report is provided for information only and are representative of site conditions at time of geotechnical investigation. Contractor is responsible to verify site conditions.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Provide settlement markers, piezometers, and other geotechnical instruments in accordance with the submitted dewatering plan or as specified.
- B. Provide casings, well screens, piping, fittings, pumps, power, and other items required for dewatering system.
- C. Provide sand and gravel filter around the well screen. Wrapping geotextile fabric directly around the well screen shall not be allowed.
- D. When deep wells, well points, or vacuum well points are used, provide pumping units capable of maintaining high vacuum and handling large volumes of air and water at the same time.
- E. Provide auxiliary dewatering equipment in the event of breakdown. Equipment shall consist of pumps and hoses and be stored on site. Provide at least one auxiliary pump for every five pumps used.
- F. Provide and maintain erosion and sedimentation control devices as indicated or specified and in accordance with the dewatering plan.
- G. Provide temporary pipes, hoses, flumes, or channels for the transport of discharge water to the discharge location.
- H. Provide cement grout having a water cement ratio of 1 to 1 by volume.

3.01 INSTALLATION:

- A. Execution of earth excavation, installing earth retention systems, and dewatering shall not commence until the related submittals have been reviewed by the Engineer with all Engineer's comments satisfactorily addressed and the geotechnical instrumentation has been installed.
- B. Provide and maintain dewatering system in accordance with the dewatering plan.
- C. Carry out dewatering program in such a manner as to prevent undermining or disturbing foundations of existing structures or of work ongoing or previously completed.
- D. Do not excavate until the dewatering system is operational.
- E. Unless otherwise specified, continue dewatering uninterrupted until all structures, pipes, and appurtenances below groundwater level have been completed such that they will not be floated or otherwise damaged by an increase in groundwater elevation.
- F. Discontinue open pumping from sumps and ditches when such pumping results in boils, loss of fines, softening of the ground, or instability of the slopes. Modify dewatering plan and submit revised plan to the Engineer for acceptance.
- G. Where subgrade materials are disturbed or become unstable due to dewatering operations, remove and replace the materials in accordance with Section 31 23 00.
- H. Dewatering Discharge:
 - 1. Install sand and gravel filters in conjunction with well points and deep wells to prevent the migration of fines from the existing soil during the dewatering operation.
 - 2. Transport pumped or drained water to discharge location without interference to other work, damage to pavement, other surfaces, or property.
 - 3. Provide separately controllable pumping lines.
 - 4. The Engineer reserves the right to sample discharge water at any time.
 - 5. Immediately notify the Engineer if suspected contaminated groundwater is encountered. Do not pump water found to be contaminated with oil or other hazardous material to the discharge locations.
- I. Monitoring Devices and Records:
 - 1. Install, maintain, monitor, and take readings from the geotechnical instruments in accordance with the dewatering plan.
 - 2. Install settlement markers on structures within the zone of influence for dewatering a distance equal to twice the depth of the excavation, from the closest edge of the excavation. Conduct and report settlement surveys to 1/8-inch.

3. For large rectangular, square, or circular mass excavations the zone of influence shall be defined by the actual cone of dewatering influence corresponding to a 10 percent increase in effective vertical stress.

J. Install and maintain erosion/sedimentation control devices at the point of discharge as indicated or specified and in accordance with the dewatering plan.

K. Removal:

1. Do not remove dewatering system without written acceptance from the Engineer.
2. Backfill and compact sumps or ditches with screened gravel or crushed stone wrapped with geotextile fabric in accordance with Section 31 23 00.
3. All dewatering wells shall be abandoned upon completion of the work, and completely backfilled with cement grout.

3.02 CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 31 23 33
TRENCHING AND BACKFILL

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide trenching and backfill as indicated and in compliance with Contract Documents.
- B. Section includes:
 - 1. Trench excavation width and safety.
 - 2. Backfill materials and placement.
 - 3. Utility identification using marking tape and trace wire
 - 4. Soil and aggregate materials.
 - 5. Compaction and testing.

1.02 REFERENCES:

- A. American Association of State and Highway Transportation Officials (AASHTO) Publications:
 - 1. M147: Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses.
- B. American Public Works Association (APWA):
 - 1. Public Works Management Practices Manual; latest edition.
- C. ASTM International (ASTM):
 - 1. C33: Specification for Concrete Aggregates.
 - 2. C150: Standard Specification for Portland Cement.
 - 3. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - 4. D75: Standard Practice for Sampling Aggregates.
 - 5. D421: Practice for Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants.

6. D422: Test Method for Particle-Size Analysis of Soils.
7. D698: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³)).
8. D1556: Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
9. D1557: Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft³ (600 kN-m/m³)).
10. D2167: Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
11. D2321: Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
12. D2419: Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
13. D2434: Standard Test Method for Permeability of Granular Soils (Constant Head).
14. D2487: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
15. D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
16. D2940/D2940M: Standard Specification for Graded Aggregate Material For Bases or Subbases for Highways or Airports.
17. D4318: Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
18. D4832: Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
19. D6938: Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

D. State Department of Transportation (DOT) :

1. UDOT Specifications: Utah Department of Transportation, 2023 Standard Specifications for Road and Bridge Construction.

E. Occupational Safety and Health Administration (OSHA) Standards and Regulations:

1. 29 CFR 1926, Subpart P: Safety and Health Regulations for Construction, Excavations.

1.03 CLASSIFICATION OF EXCAVATION:

- A. Excavation is part of the bid item for pipeline installations paid for at lump sum or linear foot as defined in the Bid Schedule.

1.04 DEFINITIONS:

- A. Percent Compaction or Compaction Density: The field dry density of compacted material, expressed as a percentage of the maximum dry density.
- B. Field Dry Density or Field Density: In-place density as determined by ASTM D1556 (Sand Cone Method), ASTM D2167 (Rubber Balloon Method), or ASTM D6938 (Nuclear Method).
- C. Maximum Dry Density: Laboratory density as determined by ASTM D698 (Standard Proctor) or ASTM D1557 (Modified Proctor) and occurring at the optimum moisture content of the soil being tested.
- D. Pipe Embedment: Comprised of the following or combination thereof:
 - 1. Foundation: Required only when the native trench bottom does not provide a firm working platform or the necessary uniform and stable support for the install pipe.
 - 2. Bedding: Placed directly underneath the pipe and brings the trench bottom to grade. Provides a firm, stable, and uniform support of the pipe.
 - 3. Haunching: From bottom of pipe to springline.
 - 4. Initial Backfill: From top of bedding or foundation to 12 inches above top of pipe, unless noted otherwise.
 - 5. Final Backfill: Above the initial backfill to a level below that required for the trench restoration area.
 - 6. Backfill: Includes initial and final backfill.

1.05 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 - 1. Qualifications of Independent Testing Laboratory, four weeks prior to earthwork.
 - 2. Temporary excavation and shoring drawings for worker protection in accordance with the General Conditions.
 - 3. Gradation analysis.
 - 4. Dewatering plan including disposition of groundwater.

5. Materials Sources: Name of source, location, date of sample, sieve analysis, and laboratory compaction characteristics.
6. Test and Evaluation Reports:
 - a. Field density testing reports: Provide results from field density testing of prepared subgrade and compacted fill.
 - b. Grain-size analysis.
 - c. Laboratory compaction characteristics of soils.
 - d. Water content.
7. Compaction method and removal sequence of shoring.
8. Mix design and test results for controlled low-strength material (CLSM).

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sustainability Standards Certifications.
- C. Sample backfill materials in accordance with ASTM D75.
- D. Provide testing in accordance with Part 3 of this section.
 1. Employ an independent testing laboratory with the following qualifications: Accreditation by the American Associates of State Highway and Transportation Officials (AASHTO) Accreditation Program.
 2. Minimum of three years experience in sampling, testing and analysis of soil and aggregates, and monitoring field compaction operations. Minimum of three references from previous work.
- E. Protect excavations by shoring, bracing, sheet piling, underpinning or other methods required to prevent cave-in of loose soil. Protection shall be in accordance with OSHA 29 CFR 1926, Subpart P.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Provide geotextile fabric in rolls wrapped with protective covering to protect geotextile fabric from mud, dirt, dust, and debris. Label each roll of geotextile fabric with number or symbol to identify production run.

- C. Protect geotextile fabric from sunlight during transportation and storage. Do not leave geotextile fabric exposed to sunlight for more than two weeks during installation operations.

1.08 SITE CONDITIONS:

A. Existing Conditions:

1. Geotechnical Report: The report is attached for information only and is not part of the contract documents. Logs of borings are included in the report and indicate conditions encountered only at test boring locations. Nothing in the contract documents shall be construed as guarantee that other materials will not be encountered or that proportion of materials will not vary from proportions shown on the logs of test borings.

PART 2 - PRODUCTS

2.01 BACKFILL MATERIALS:

- A. Stabilization Material for Foundation: Stabilization material shall consist of hard, durable particles of stone or gravel, screened or crushed to the required size and gradation. The material shall be free from vegetation matter, lumps or balls of clay, or other deleterious matter and shall conform to the following gradation when tested in accordance with AASHTO T27 or ASTM C136.

1. Coarse material shall be crushed or washed and fine material shall be wasted to meet the grading requirements set forth below. Note that if stabilization material is required, an 8 oz. non-woven filter fabric shall be placed between the stabilization material and the pipe zone material.
2. Coarse aggregate, retained on the No. 4 sieve, shall have a percentage of wear not greater than 40 percent when tested by the Los Angeles Test, AASHTO T-96 or ASTM C 131.

- B. Pipe Zone Material: All material in the pipe zone shall be clean and free from alkali, salt, petroleum products, vegetative matter or other deleterious matter, slag, cinders, ashes and rubbish, recycled RAP, or other material that in the opinion of the ENGINEER may be objectionable or deleterious. "Squeegee" or any other flowable material shall not be permitted. Pipe zone material shall conform to the following:

1. Rigid Pipelines - RCP – Gravel, 100 percent crushed mineral aggregate per the following gradation:

Sieve Size	Percentage Passing
1-1/2 inch	100
1 inch	95 to 100
1/2 inch	25-60
No. 4	0-10
No. 200	0-5

2. Flexible Pipelines - DIP– Sand per the following gradation:

Sieve Size	Percentage Passing
3/8 inch	100
No. 10	30-60
No. 40	0-30
No. 200	0-15

3. HDPE and Steel Pipeline - Controlled Low-Strength Material (Flowable Fill) as specified in Section 03 31 05 Controlled Low Strength Material.

- C. Granular Trench Backfill: Granular trench backfill may be imported or native fill materials and shall consist of materials meeting soils classifications A-1, A-2 or A-3 of AASHTO M145, with a maximum particle size no greater than 3-inches in any dimension and shall be capable of meeting the compaction requirements. Trench backfill shall be non-plastic. Trench backfill shall be free from alkali, salt, petroleum products, vegetative matter or other deleterious matter, slag, cinders, ashes and rubbish, recycled RAP, or other material that in the opinion of the ENGINEER may be objectionable or deleterious. “Squeegee” or any other flowable material shall not be permitted.

2.02 EQUIPMENT:

- A. Compaction equipment shall be capable of consistently achieving the specified compaction requirements.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify that dewatering support systems are in place before commencing with excavation.
- B. Verify that excavation safety and support systems meeting the requirements of OSHA 29 CFR 1926, Subpart are in place before commencing with excavation.

1. Minimum slopes for laying back excavations or materials are contained in OSHA 29 CFR 1926, Subpart P; Appendices A and B.
 2. Minimum requirements for shoring and bracing are contained in OSHA 29 CFR 1926, Subpart P; Appendix C
- C. Verify that fill materials submittals have been accepted by Engineer before commencing with work requiring the use of these materials.
- D. Verify that erosion and sediment control measures are in place and functioning properly.
- E. Immediately notify the Engineer if unexpected subsurface facilities or suspected hazardous materials are encountered during excavation. Discontinue affected work in area until notified to resume work.
- F. Test Pits:
1. Comply with the requirements in Section 01 14 14.
 2. Excavate test pits to field verify the locations of existing underground utilities at crossings and at tie-in points before ordering materials or commencing excavation. Immediately notify the Engineer if conflicts are encountered.
- 3.02 PREPARATION:
- A. Underpin adjacent structures that could be damaged by excavation work.
 - B. Cut pavement with saw or pneumatic tools to prevent damage to remaining pavement. Dispose of large pieces of demolished pavement before proceeding with excavation.
- 3.03 PROTECTION OF IN-PLACE CONDITIONS:
- A. Comply with the requirements specified in Section 01 14 14.
 - B. Support and protect from damage – existing pipes, poles, wires, fences, curbs, property line markers, and other features or structures which must be preserved in place to avoid being temporarily or permanently relocated.
 - C. Excavation Near Existing Structures:
 1. Discontinue digging by machinery when excavation approaches pipes, conduits, or other underground structures. Continue excavation by use of hand tools. Include such manual excavation in work to be done when incidental to normal excavation and under items involving normal excavation.
 2. Excavate test pits near, or at intersection with, existing utilities or underground structures to determine the exact location of existing features.
 - D. Excavation Near Private Property:

1. Record existing condition of features on adjacent property by means of dated photographs or cameras. Provide construction photographs according to Section 01 32 33.
2. Enclose uncut tree trunks adjacent to work in wooden boxes of such height necessary to protect tree from injury due to piled material, equipment, or operations. Operate excavating machinery and cranes so as to prevent injury to overhanging branches and limbs.
3. Protect cultivated hedges, shrubs, and plants which would otherwise be damaged by the work.
4. Where protection of vegetation is not possible, dig up, temporarily transplant, and maintain. After active construction operations in the area have ceased, transplant vegetation to the original positions and provide water and nursery care until growth is re-established.
5. Do not use or operate tractors, bulldozers, or other power-operated equipment on paved surfaces. Provide protection on pavement or tracks if construction traffic is unavoidable.

3.04 RESTORATION:

- A. Restore private property and structures promptly. Begin restoration work within 24 hours of when damage occurred.
- B. Existing surfaces, features, or utilities that are to remain but are damaged during construction shall be repaired or replaced to at least the condition in which they were found immediately before work began, unless noted otherwise.
- C. Damaged Trees To Remain: Cut all damaged branches, limbs, and roots smoothly and neatly without splitting or crushing. Neatly trim, cut the injured portions and cover with an application of grafting wax or tree healing paint. Replace damaged trees which subsequently die or continue to show lack of growth due to damage, one year after substantial completion.
- D. Cultivated Vegetation: Includes, but is not limited to, hedges, shrubs, and plants. Vegetation that is damaged shall be replaced with equal kind and of at least the quality before work began.

3.05 TRENCH EXCAVATION:

- A. Provide dewatering system to allow for working conditions in dry, stable soil. Properly dispose of water to avoid damage to property and in accordance with laws and regulations. Lower groundwater table prior to excavation and keep a minimum of 24 inches below lowest excavation subgrade until structure has sufficient strength to withstand soil and water pressures.

- B. Sheet and brace trenches, excavations, and adjacent structures to comply with laws and regulations and to provide protection of life, property, and the Work. Where close sheeting is necessary, drive to prevent adjacent soil from entering excavation. Remove close sheeting only when removal would not damage property or the Work. Sheeting shall not be left in place.
- C. Preserve material below and beyond the lines of excavations.
- D. Locate stockpiled excavated material at least 3 feet from edge of excavations to prevent cave-ins or bank slides.
- E. Bottom Preparation:
 - 1. Where rock, hard pan, boulders or other material which might damage the pipe are encountered, the bottom of the trench shall be over excavated 4 inches below the required grade and replaced with Stabilization Material. Otherwise, the bottom of the trench shall be over excavated 6 inches or 1/12 the outside diameter of the pipe, whichever is greater, below the required grade and replaced with Pipe Zone Backfill.
 - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Bell holes shall be excavated to the necessary size at each joint or coupling to eliminate point bearing. Stones of 1-inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.
 - 3. If the soils at the base of the pipeline excavations consist of higher clay content or looser sands, then it may be necessary to increase the thickness of the bedding layer to approximately 18 to 24 inches with geotextiles placed on the base of the trench and extending up to the spring line of the pipe, depending on the stability of the soil at the time of construction. Backfill shall be Stabilization Material or Pipe Zone Backfill.
- F. Removal of Unstable Material
 - 1. Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed by Engineer and replaced to the proper grade with Stabilization Material. When removal of unstable material is required due to the fault or neglect of Contractor in his performance of the work, the resulting material shall be excavated and replaced by Contractor without additional cost to Owner.
- G. The trench bottom (at the level of the base of the pipe) shall be given a final trim using a string line, laser, or another method approved by Engineer for establishing grade, such that each pipe section when first laid will be continually in contact with the ground along the extreme bottom of the pipe. Bell holes shall be provided at each joint to permit the jointing to be made properly. The trench grade shall permit the pipe spigot to be accurately centered in the preceding laid pipe joint, without lifting the pipe above the grade, and without exceeding the permissible joint deflection.

3.06 UNAUTHORIZED EXCAVATION:

- A. Contractor is responsible for backfilling unauthorized excavations with bedding material.

3.07 BACKFILL:

- A. Fill to lines and grades necessary to provide finish grades.
- B. Use a placement method that does not disturb or damage other work or existing features.
- C. Maintain fill materials within optimum moisture, to attain required compaction density.
- D. Place and compact material in equal continuous layers.

E. Pipe Zone:

1. Pipe Zone Backfill shall be placed in layers not exceeding 6 inches loose thickness for compaction by hand operated machine compactors, and 8 inches loose thickness for other than hand operated machines, unless otherwise approved or specified. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe. Each layer shall be compacted to at least 95 percent of the maximum Modified Proctor density (ASTM D-1557), unless otherwise specified or indicated in the geotechnical report.
2. Replacement of Unyielding Material: Unyielding material removed from the bottom of the trench shall be replaced with Stabilization Material placed in layers not exceeding 6 inches loose thickness.
3. Replacement of Unstable Material: Unstable material removed from the bottom of the trench or excavation shall be replaced with Stabilization Material placed in layers not exceeding 6 inches loose thickness.
4. Where the pipe grade exceeds 30%, cohesive material shall be used in lieu of pipe bedding. The cohesive material shall be moistened to within 2% of optimum moisture and compacted as noted.
5. The relative density of the compacted cohesionless material shall not be less than 60% as determined by the Bureau of Reclamation Relative Density of Cohesionless Soil Test (Designation E-12) of the "Earth Manual."

F. Trench Backfill: Trenches shall be backfilled to the grade shown with Trench Backfill material as specified.

1. Trench backfill in asphalted road shall consist of backfilling the trench from above the pipe zone up to underneath the noted recommended depth for untreated base course and asphalt or concrete of finished grade with Trench Backfill material compacted to at least 95 percent of maximum density (ASTM D-1557), unless

otherwise specified or indicated in the geotechnical report. Backfill shall be placed in layers not exceeding 6-inches loose thickness for compaction by hand operated machine compactors, and 8 inches loose thickness for other than hand operated machines, unless otherwise approved or specified.

2. Trench Backfill in unimproved or landscaped areas shall consist of backfilling the trench from above the pipe zone to 8-inches below finished grade with Trench Backfill material compacted to 90 percent of maximum density (ASTM D-1557), unless otherwise specified or indicated in the geotechnical report. Backfill from 8-inches below finished grade to finished grade shall consist of topsoil replacement in addition to replacement of all landscaped materials. Trench Backfill shall be placed in layers not exceeding 8 inches loose thickness.
3. It shall be the responsibility of Contractor to be assured that the Trench Backfill material is capable of being compacted to the degree specified. It shall be Contractor's responsibility to remove and dispose of all excess excavated material.

G. Final Backfill:

1. Unimproved and Landscaped Areas: The top 8-inches of the trench shall be filled with topsoil. Topsoil may be native material stripped prior to excavation of the trench. Backfill shall be deposited in layers of a maximum of 12-inch loose thickness and compacted to a minimum of 85 percent maximum density (ASTM D-1557). Compaction by water flooding or jetting will not be permitted. This requirement shall also apply to all other areas not specifically designated above.
2. Roadways shall be completed with the type and thickness of materials (i.e., Untreated Road Base and Asphalt) as indicated or shown on the Contract Drawing.

3.08 CLSM PLACEMENT:

- A. Place the CLSM so that it flows easily into all openings between the pipe and the excavated trench. In some cases, such as trenches on a slope, a stiffer mix may be required to prevent it from flowing down the trench. In this case, use vibration to ensure that the CLSM completely fills all spaces.
- B. Lay the pipe on the soil pads and place the CLSM bedding as shown in the drawings. Place bedding under pipe from one side and vibrate so that it flows under the pipe until it appears on the other side. Then add CLSM to both sides of the pipe and vibrate until it completely fills the space between the pipe and the excavated trench bottom. This operation shall follow as closely behind pipe laying operations as possible. Place CLSM in such a way as to prevent uplift or buckling of the pipe. Deposit CLSM as nearly as practicable in its final position. Do not disturb the pipe trench or cause foreign material to become mixed with the cement slurry.
- C. Do not place backfill above the pipe until the CLSM has reached the initial set. Place and maintain a 6-inch cover of moist backfill cover until additional backfill is placed. If the

ambient temperature is 50 degrees F or less, place an additional 6-inch cover of backfill over the moist backfill cover prior to the end of the working day.

- D. Whenever freezing temperatures are imminent, maintain the CLSM at a temperature of not less than 50 degrees F for 24 hours after placement. The temperature of the mix shall be 50 degrees F or greater at the time of placement. Monitor the temperature by placing a thermometer in the CLSM immediately after sampling at the placement site. When freezing weather appears imminent, make ready at the placement site materials that may be required for protection of the CLSM. Delay placement of CLSM until adequate provisions for protection against weather are made. Do not place CLSM bedding in pipe trenches when the trench bottom or walls are frozen or contain frozen material. Backfill placed as cover over the CLSM is prohibited from containing any frozen material.

3.09 SPECIAL REQUIREMENTS

- A. Special requirements for both excavation and backfill relating to the specific utilities from above the pipe zone to the natural surface level or the finished grade indicated on the Plans shall be placed and compacted as follows:
 - 1. Where existing underground pipes or conduits larger than 3 inches in diameter and all sizes of sewer lines or sewer laterals cross the trench above the new work, the backfill from the bottom of the trench to 1 foot above the top of the intersecting pipe or conduit shall be pipe zone material compacted to 95 percent of maximum density (ASTM D-1557). The pipe zone material shall extend 2 feet on either side of the intersecting pipe or conduit to ensure that the material will remain in place while other backfill is placed.
- B. The maximum trench length open at any given time shall not exceed 200 feet unless approved by ENGINEER and must be backfilled in a timely manner.

3.10 COMPACTION:

- A. Compact to density specified and indicated for various types of material. Control moisture content of material being placed as specified, or if not specified - at a level slightly lower than optimum.
- B. Compaction Density: Provide trench backfill densities according to Table 31 23 33-4. The values listed are minimum percentages, unless noted otherwise.

Table 31 23 33-4	
Area	Percentage of Maximum Dry Density as defined by ASTM D1557 (Modified Proctor)
Trench Backfill (under pavement, slabs)	95
Trench Backfill (under structures or within 25 feet (7.5 m) of structures)	95
Trench Backfill (through embankment)	98
Trench Backfill (under exterior concrete slab and sidewalks)	95
Trench Backfill (in open or grassed areas)	90

3.11 UTILITY IDENTIFICATION:

- A. Install marking tape over all site utilities, 18inches above pipeline.
- B. Install trace wire at top center of pipeline; pull wire taut to remove any slack.
- C. Extend trace wire to utility boxes, manholes and junctions to allow for connection to subsurface location equipment.

3.12 FIELD QUALITY CONTROL:

- A. See Section 01 40 00 for general requirements for field inspection and testing.
- B. Compaction shall be deemed to comply with the specifications when no more than one (1) test of any 3 consecutive tests falls below the specified relative compaction. The one test shall be no more than 3 percentage points below the specified compaction. The Contractor shall pay the costs for any retesting or additional testing of work not conforming to the specifications.
- C. Where compaction tests indicate a failure to meet the specified compaction, the Owner will take additional tests every 25 feet in each direction until the extent of the failing area is identified. Rework the entire failed area until the specified compaction has been achieved.
- D. Perform particle size distribution and gradation analyses using ASTM D422 and following standard practices in ASTM D421. Perform one (1) test for every source and submit results to Engineer for acceptance. Repeat the moisture density test for every 5,000 cubic yard of material used.
- E. Perform field density testing in accordance with ASTM D1556, ASTM D2167, or ASTM D6938.

- F. Evaluate field density test results in relation to maximum dry density as determined by testing material in accordance with ASTM D1557 (Modified Proctor).
- G. Perform tests in accordance with ASTM D4318 to determine Liquid Limit, Plastic Limit and Plasticity Index and submit test results to Engineer for acceptance. Minimum of one test per 5,000 cubic yard of soil for use as fill material and whenever classification of material is in doubt as determined by the Engineer.
- H. Location of field density tests shall be mutually acceptable to testing laboratory and the Engineer.
- I. Frequency of field density tests:

Table 31 23 33-5	
Area	Frequency
Trench	1 per lift for each 200 linear feet of trench
Regardless of the minimum testing frequency specified, field density tests shall be performed by the Contractor in sufficient number for the Contractor's quality control purposes to ensure that specified density is obtained.	

- J. Owner may retain the services of an independent testing laboratory to conduct confirmatory testing and inspection.

3.13 ADJUSTING:

A. Shrinkage:

1. Backfill to a height above finished grade which will allow for the shrinkage or consolidation of material. Initially, provide at all points, an excess of at least one percent of total height of backfill measured from stripped surface to top of finished surface.
2. Supply specified materials and build up low places, without additional cost if embankment or backfilling settles so as to be below the indicated level for proposed finished surface at any time before final acceptance of the work.

3.14 PROTECTION:

- A. Formulate excavation, backfilling, and filling schedule and procedures to eliminate possibility of undermining or disturbing foundations of partially and completed structures, pipelines and embankments or existing structures and pipelines.

3.15 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 70 00.

END OF SECTION

SECTION 31 24 02

GROUND IMPROVEMENT USING SOIL MIX COLUMNS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This specification covers the following items of work:
1. Furnishing all labor, supervision, equipment, and materials necessary to perform a soil mix column performance-based design, test section and install production soil mix columns within the improvement zones and depths as shown on the Contract Drawings and herein in this Specification with all associated acceptance testing, monitoring, sampling, recording, and site restoration and provide all associated documentation.
 2. Evaluate site conditions and data provided and perform any additional investigation, testing or analysis materials necessary to complete the design and a compliant installation.
 3. Deliver and place all materials necessary in the improvement process.
 4. Collect, store, and dispose of all spoils and water produced by the installation process, including groundwater that may rise to the surface during installation.
 5. Monitor and mitigate impacts of the ground improvement operation on existing utilities, roadways, and nearby structures, including, but not limited to potential vibrations, settlement, heave, and coordination with other site activities.
 6. Perform and document post installation testing to verify the required level of improvement.

1.02 DEFINITIONS

- A. Contractor – refers to the general contractor for the Project.
- B. Ground Improvement (GI): Treating soil in situ by soil-cement mixing technology. Ground Improvement Columns (GIC) are formed by soil-mixing shaft(s) guided by a lead mounted on a crawler base machine. The mixing shaft(s) shall be driven by a power source sufficient to provide torque for a wide range of drilling conditions and to maintain continuous installation of GIC. As the mixing shaft(s) are advanced into the soil, Portland cement grout is pumped through the hollow stem of the shaft(s) and injected into the soil at the shaft tip(s). Auger flights and mixing blades on the shaft(s) blend the soil with grout in a pugmill fashion. When the design depth is reached, the mixing shafts are withdrawn while the mixing process is continued. In some cases, the mixing shaft(s) are positioned to overlap one another, forming continuously-mixed overlapping columns.

- C. GI Contractor – refers to the subcontracted ground improvement contractor for the Project.
- D. Grout: A stable mixture of water, Portland cement, and possibly admixtures. The purpose of the grout is to assist in loosening the soils for penetration and optimum mixing, and upon setting, to decrease the compressibility and increase the strength of the in-situ soil.
- E. Grout-Soil Ratio: A volumetric ratio of grout to *in situ* soil to be mixed.
- F. Cement Content in Place: The ratio of cement (in terms of dry weight) used to treat a given volume of in situ soil and the grout volume.
- G. Mixing Spoils: All materials including liquids, semi-solids, and solids that are discharged above ground surface during or because of GI operations.
- H. Quality Control Testing Laboratory: An independent testing laboratory retained by the Contractor that is responsible for obtaining and testing GIC specimens for quality control. Testing costs for the Provo River Water Treatment Plant area shall be incurred by the GI Contractor.
- I. Working Platform Level: The ground surface level from which the GI is installed.
- J. Pre-Drilling: Performed up to an equivalent diameter, up to the design depth to move soil, reduce the mixing resistance or remove obstructions.

1.03 GROUND IMPROVEMENT DESIGN

- A. The GI Contractor shall design patterns based on soil mixing technology to satisfy requirements for the treatment zone specified herein. GI Design submittal shall include a Quality Control Plan confirming required acceptance criteria which shall be submitted to the Engineer for review and approval.
- B. This specification is for installation of soil mix columns. Alternate bids using Aggregate Columns, Section 31 24 03, will be considered.
- C. Use a qualified, Utah registered professional engineer experienced in GI to design GI including column size and layout and provide supporting calculations.
- D. Design requirements include, but are not limited to, the analysis to conform the GI treatment adequately satisfied the site performance criteria. The GI Contractor design shall be responsible to obtain adequate site soil samples, to perform lab mixing tests and determined the mixing binder dosage, and all the soil-cement design and mixing parameters.
- E. Performance criteria documented by the design analysis shall provide the following ground control for foundation support of all structures in the mitigation area:
 - 1. A minimum area replacement ratio of 0.25. The Contractor may include an alternative providing a line item deduct for consideration by the Owner using a

lower area replacement ratio if accompanied by attached supporting design and calculations or modeling (sealed by a Utah registered professional engineer) demonstrating conformance to other performance criteria below.

2. A minimum bearing capacity of 6,000 pounds per square foot.
3. Mitigation of static settlement to less than one inch.
4. Mitigation of seismic shaking and liquefaction settlement to less than three inches, using the 2021 method of analysis including its approach for silts where applicable. (ref. Boulanger & Shao, 2021).

F. Site Preparation by the Contractor:

1. The building pads identified on the plan will be over-excavated to the elevation shown on the Contract Drawings. The Contractor will provide GI Contractor a flat, dry, stable working platform, suitable for the soil mixing equipment operation.

G. Contract Work Includes:

1. In accordance with the specifications contained in this Section and as shown on the plans, the GI Contractor shall furnish all plant, equipment, labor, and materials required to construct all the GI as indicated in the Contract Documents.
2. The GI Contractor shall determine and be responsible for providing all mixing binder material.
3. Construct GI in area shown on the plans.
4. Implement the Quality Control Plan and provide all submittals and documentation as required in these specifications, include, but are not limited to monitor the mixing tool penetration depth, RPM, grout flow rate and specific gravity, etc., provide daily production/QC reports, provide remixing or repair plans as needed, collect wet soil mixing samples every shift and transport the samples to an accredited laboratory (Lab) for Unconfined Compressive Strength (UCS) testing, drill confirmation core holes at randomly selected Ground Improvement Column (GIC) locations.

H. Owners Representative

The Owner's Quality Assurance (QA) representative Engineer for the Provo River Water Treatment Plant project (Project) will be AECOM. They will perform the following the following tasks:

1. Observe and document soil improvement activities.
2. Log confirmation core borings drilled at selected GIC locations.
3. Select locations of confirmation core borings.

4. Accept and transport core samples to the Lab to cure samples to the planned test dates.
5. Oversee UCS tests performed by the Lab on selected wet and core samples and evaluate the test results.
6. Prepare a final report that will include a summary of field observations, laboratory test data and an opinion as to whether the GI meets the acceptance criteria. The final inspection report will be submitted to the Engineer and the Owner for review and approval.

1.04 REFERENCES

A. Standards

The following publications form a part of this specification to the extend referenced.

1. American Concrete Institute (ACI).
2. American Society of Testing and Materials (ASTM) ASTM D1143: Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.
3. ASTM D1586: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
4. ASTM D5778: Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.

B. References

1. Geotechnical Report, Attachment A: The report is attached for information only. GI Contractor shall base their design on their own assessment of site geotechnical conditions and proposed foundation system.
2. Applicable Contract Drawings including improvement area plan and underground utilities plan.
3. Contract Documents.
4. EERI, 2010. Liquefaction Monograph.
5. Boulanger & Shao, 2021. Liquefaction Mitigation with Deep Mixing, Proceedings Deep Mixing 2021 Conference, Deep Foundations Institute, June 2021.

1.05 SUBMITTALS

A. Qualifying experiences:

1. The following shall be submitted to and approved by the Engineer:

2. Qualifying Experience. The GI Contractor shall have at least 10 years of documented cement deep soil mixing experience and minimum of five deep soil mixing projects.
 - a. Submit a copy of the last five completed cement deep soil mixing projects including the job name, date, location, project description, treated cubic yards and professional references.
3. Qualifying Individual Experiences. The subcontractor shall submit the name and resume of the proposed individuals for the following job classifications. Resume shall include the individual's number of years of experience, project name, project descriptions and references.
 - a. Utah registered Engineer with geotechnical training and experience who will be responsible to prepare and manage the design and construction of the cement deep soil mixing program, including the mix design and drawings, and to review the QC/QA records, as-built drawings and to confirm that the GI work meets the design intent. Minimum of five years of experience designing GIC projects required.
 - b. All quality control/quality assurance supervisor(s), testing technician(s), and laboratory technician(s) shall have a minimum of one year of experience in cement deep soil mixing.
 - c. Project manager shall have managed a minimum of five years of experience managing GIC projects. The project manager shall be on-site for at least half of each shift.
 - d. Project Superintendent shall have five years of experience as GI Superintendent.
 - e. Two Equipment Operators shall each have a minimum experience of two GIC Projects. One of the two operators must be continuously onsite during each shift.
 - f. Grout Mixing Plant Operator shall have a minimum experience of two GIC projects. The operator must have experience operating the same equipment that will be utilized onsite.
4. Personnel Substitutions: The cement deep soil mixing contractor must submit a formal request in writing to the Owner and Engineer to request the substitution of any personnel previously approved by the Owner and Engineer. Personnel substitutions will not be granted in the event the experience level of the substituted professional(s) is less than required above.

B. Design Performance Criteria

Evidence of conformance to the referenced standards and requirements shall be submitted for the following:

1. Final GI Design Plan: The GI Contractor shall submit a Final GI Plan for review and approval by the Engineer. This Final GI Design Plan shall be a deferred submittal, and must gain all approval from Engineer, prior to start of work. This design should include:
 - a. Grout Mix: Proposed mix designs including all materials and quantities and documentation of calibration of the mixing plant. The mix design shall be supported by the GI Contractor lab mixing program.
 - b. GIC Layout and Construction Sequence: The GIC layout shall include at a minimum: individual column designations, column center coordinates (northing and easting coordinates to the nearest 0.1 feet), and anticipated column lengths (based on depth elevations shown in the plans). The GIC layout shall meet the horizontal alignment requirements of 3.02 herein. The anticipated column construction sequence shall be included in the submittal.
 - c. Equipment and Procedures: Submit a detailed description of the equipment and procedures to be used during all facets of the project including, but not limited to, predrilling, construction of GIC, monitoring the quality control parameters outlined in 1.04.C herein, and the collection of samples for laboratory confirmation testing. Procedures shall include methods for locating the GIC in the field and confirming that the columns are plumb. The GI Contractor shall also submit the anticipated cement dosages to achieve the acceptance criteria outlined in 3.06 herein.
 - d. Quality Control Program: The Contractor shall submit a detailed work plan for the Quality Control Program. The work plan shall include, as a minimum, a description of all procedures to be implemented, parameters to be monitored, tolerances for the parameters monitored, and the names of any subcontractors used for testing.
2. Cement: Certificate for each truck load delivery, if requested.
3. Admixtures: If used.
4. Construction Schedule: Submit a detailed schedule that identifies start dates and duration of each major task in the work. The schedule shall include information regarding a lab strength testing program for the GI area, equipment mobilization, equipment setup, GI production installation, and verification testing.
5. Mixing Spoils: Submit sketches and narrative that describe the procedures to collect, contain, and temporarily store mixing spoils. Temporary storage area and spoil

storage areas shall be identified and coordinated with the owner and prime contractor.

C. Daily Production/Quality Control Report:

1. Submit the Daily Production/Quality Control Report at the end of next working day. Fill out the Daily Production/Quality Control Report, check for correctness, and have it signed by the GI Contractor's field superintendent. The report shall be in conformance with requirements herein.
2. The report shall contain, but not be limited to, the following information:
 - a. Day, month, year, time of beginning and end of work shift; name of each superintendent in charge of the work for the GI Contractor; a list of all worker names associated with each GIC rig; and a summary of equipment used during the shift.
 - b. Details of predrilling activities, including but not limited to, depth, diameter, drilling equipment, portion of boring backfill, and type of backfill materials used.
 - c. The locations, installation sequence, and as-installed top and bottom elevations of the GIC installed during the work shift, and any deviations from the planned locations and vertical alignment.
 - d. Time of start and completion of each GIC installed during the work shift and a summary of any downtime during the shift including time of work stoppage, duration, reason, and if work stoppage occurred while mixing a GIC.
 - e. Specific gravity of the cement grout, grout injection pressures and rates, quantities of cement, cement factors, cement additives, and water used, mixing rotational speeds, penetration, and withdrawal rates of the mixing equipment within every foot depth increment, and mixing time at the bottom of the column for each GIC.
 - f. Include grout batching records or real-time specific gravity coinciding with GIC installation.
 - g. Other pertinent observations including, but not limited to, the operator's log including a description of the drill rig performance, operator observations, description of spoil returns, cement grout escapes, ground settlement and/or heave, collapses of the GIC, remixing of columns, obstructions, and any unusual behavior of the equipment during the GI process.
 - h. All electronic data collected from all the GIC shall be submitted to the Owner on an electronic media, or printed sheets before the completion of the next soil mixing shift.

- i. Logs of core borings and records of GIC wet grab samples and core samples taken during the work shift including sample designation, date, time, plan location, elevation, and the name of the firm and person(s) obtaining the samples.
 - j. The report shall include as a minimum the results of the following QC parameter monitoring for each GIC:
 - (1) Rig number.
 - (2) Type of mixing tool.
 - (3) Date and time (start and finish) of GIC construction.
 - (4) GIC number and reference drawing number.
 - (5) GIC average diameter and length.
 - (6) GIC top and bottom elevations.
 - (7) Grout mix design designation or specific gravity measurements.
 - (8) Description of obstructions, interruptions, or other difficulties during installation and how they were resolved.
 - k. The report shall also include the following parameters recorded automatically for each GIC at intervals no greater than 1.0 foot and submitted in a PDF file in either tables or figures:
 - (1) Depth vs. real time.
 - (2) Mixing blade rotation number vs. depth.
 - (3) Penetration and withdrawal rates vs. depth; and
 - (4) Grout injection rate vs. depth for each column within the GIC for each separate grout injection
 - (5) Binder content (cement weight/unit soilcrete volume) vs depth for each GIC.
- D. Remixing or Repair Plan: If the GIC acceptance criteria are not achieved the GI Contractor shall submit to the Owner a proposed plan for remixing, or adding columns, or repair of failed sections for review and approval.
- E. GIC Samples: Submit GIC samples (other than those required for the GI Contractor testing) as outlined in 1.01 D.4 herein at the end of each day that the samples are collected.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Grout: The material added to the blended *in situ* soils shall be a water-based Portland cement grout. The grout shall be premixed in a mixing plant which combines dry materials and water in predetermined proportions. The grout shall not have begun its initial set before it is injected into the ground. The grout must be used within three hours of first mixing or be discarded.
- B. Portland Cement: Cement shall conform to ASTM C150 "Standard Specification for Portland Cement" Type II/V. The cement shall be adequately protected from moisture and contamination while in transit to the job site and while in storage at the job site. Reclaimed cement or cement containing lumps or deleterious matter shall not be used. Cement containing lumps or foreign matter of a nature and in amounts that might be deleterious to the grouting operations shall not be used. All cement shall be homogeneous in composition and properties.
- C. Water: Fresh water, free of deleterious substances that may adversely affect the strength and mixing properties of the grout or any substance that may be considered an environmental concern, shall be used to manufacture grout. Owner will provide water sources of up to 500 gpm.
- D. Admixtures: Admixtures are added to the mixture immediately before or during mixing. Admixtures of softening agents, dispersions, retarders or plugging or bridging agents may be added to the water or the grout to permit efficient use of the materials and proper workability of the grout. If admixtures are proposed, the GI Contractor shall provide a written statement from the manufacturer as to the use of any such admixture, its effect on the GIC material, its long-term performance and stability, and its effect on the environment.
- E. Blended Portland Cement: Additional solids such as ground slag may also be used in the grout mix design. Fly ash or other solids containing heavy metals or other substances that may be considered an environmental concern shall not be used in the grout mix design.

2.02 EQUIPMENT

- A. The GIC equipment shall meet the following requirements:
 - 1. Single or multi-shaft shaft mixing equipment is allowed. The mixing shaft(s) shall have mixing augers and blades (paddles) configured in a manner so that they are capable of thoroughly blending the in-situ soils and grout. Auger flights and mixing paddles on the shaft(s) shall extend to the full diameter of the GIC being formed.
 - 2. The power source for driving the mixing shafts shall be sufficient to maintain the required revolutions per minute (RPM) and penetration rate from a stopped position at the maximum depth required. Mixing equipment shall be capable of advancing

- through previously installed and hardened GIC material. Pre-drilling may be used to assist GIC installation.
3. The GIC rig shall be equipped with electronic sensors built into the leads to determine vertical alignment in two directions: forward-aft and left-right. The output from the sensors shall be routed to a console that is visible to the operator and the Engineer during penetration.
 4. The equipment and/or GIC overlapping technique shall be configured so that the length of the overlapping extends for the full depth of the GIC.
 5. The GIC equipment shall be adequately marked and have electronic depth display to allow the Engineer to evaluate the penetration depth to within 6 inches during construction.
 6. As a minimum, the grout shall be premixed in a mixing plant that combines dry materials and water in predetermined proportions. The mixing plant shall consist of a jet valve, grout circulation pump, variable speed cement feeding system, and a mass flow meter. The mass flow meter shall be used to accurately determine mix proportions in terms of specific gravity. The GI Contractor shall provide the calibration sheet of the mass flow meter at the beginning of the project and monthly thereafter.
 7. Progressive cavity pumps shall be used to transfer the grout from the mixing plant to the auger(s). Grout pumps shall be capable of pumping the required distance and elevations to provide and maintain an adequate supply of grout to the mixing augers or mixing tools. The grout shall be delivered to the slurry-injecting auger by an individual progressive cavity pump having an inline flow meter and pressure gauge.
 8. All equipment shall have devices to permit accurate and continuous monitoring and control of: (1) specific gravity, (2) cement-grout injection pressures and quantities, (3) mixing tool rotation speeds, (4) advancement and withdrawal rates of the mixing tools, and (5) other operations required to install and mix GI materials.
 9. Pre-drilling equipment shall be of sufficient capacity to excavate the GI bore hole to the design depth, or shallower, as required.

2.03 GROUT MIXES

- A. GIC: The grout mixed with the in-situ fill soils shall achieve an average unconfined compressive strength of no less than 150 psi at 56 days. The unconfined compressive strength (UCS) of individual samples shall be determined in accordance with ASTM D1633 "Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders." An average UCS shall be calculated for the treatment area. In calculating an average UCS, test results at 56 days for both wet samples and core samples shall be used and a ceiling, not-to-exceed value of twice the target average UCS (i.e., 300 psi) shall be used for individual samples. No more than 10 percent of all specimens in the area shall exhibit an UCS of less than 60 psi at 56 days.

PART 3 - EXECUTION

3.01 GENERAL

- A. The GI shall be constructed within the area designated and to the lines, grades, and cross section indicated on the plans. The GI shall have essentially vertical columns, with a minimum diameter of four feet and shall extend to Elevation 4578 feet. Columns shall be terminated either as shown on the plans, or at a depth determined by the GI Contractor, whichever is deeper. The completed GIC shall be a near homogeneous mixture of grout and each of the situ soil layers. Mixing is to be controlled by shaft rotational speed, drilled speed, and grout injection rate.
- B. The GIC installation may encounter obstructions in the treatment zones. In case the GI Contractor has difficulties in mixing, the GI Contractor shall perform pre-drilling to remove the obstruction in GI Contractor cost. In case pre-drilling cannot penetrate the obstruction, the GI Contractor shall provide alternative solutions to Engineer and Owner. The alternative constructions will be paid by the Owner.
- C. The Contractor shall supply the GI Contractor with a suitable working platform, capable of supporting the weight of the drill and allowing it to move from location to location without difficulty.

3.02 HORIZONTAL ALIGNMENT

- A. The GI Contractor will accurately stake the locations of the proposed GIC shown on the plans before installation. Selected locations will be verified by a surveyor provided by the Engineer. The columns shall be constructed within a tolerable distance for the plan, which the tolerance is defined as the half of the mixing columns overlap distance.
- B. Beneath the footings of the structures, the GIC shall be constructed to create a continuous wall, and all have an adequate overlap to transfer the seismic lateral loads without tensile cracks. The horizontal configuration of the GIC shall be consistent with the layout detail on the plans. The overall design shall also be configured with overlapping columns in panels or cells to resist cracking or buckling during seismic loading.
- C. Movement of the crawler base machine shall provide the preliminary alignment of the augers and the final alignment shall be adjusted by hydraulic manipulation of the leads. The GIC shall be advanced stepwise by overlapping the adjacent columns of the previous strokes where applicable.

3.03 VERTICAL ALIGNMENT

- A. Vertical alignment of the mixing shaft stroke shall be controlled by the equipment operator. Two measurements of vertical shall be monitored, the forward-aft and left-right. The GIC shall be installed at an average inclination deviating no more than 1.5% from vertical.

3.04 COLUMN DEPTH

- A. The anticipated GIC depth at each column location shall be determined by the depth elevations shown on the plans. The contour elevations represent the GI Contractor's best estimate of the approximate elevation of the base of the GIC. Columns shall be terminated either at the contour elevations shown on the plans, or at a depth revised by the GI Contractor, whichever is deeper. In no case shall the columns be terminated at an elevation higher than the contours shown on the plans. In the field, the GI Contractor shall determine the actual depth of each column, based on the soil conditions and obstacles.
- B. The total depth of penetration shall be measured either by observing the length of the inserted mixing shaft and by the on-board computer data acquisition system. The final depth of the stroke shall be noted and recorded on the Daily Production/Quality Control Report by the GI Contractor. The equipment shall be adequately marked to allow the Engineer to evaluate the penetration depth during construction.
- C. The GI Contractor is responsible for penetrating any unexcavated soil, in order to reach the bottom of the treatment zone. This includes, as necessary – excavation, predrilling, use of an advance, etc., to penetrate the treatment zone as shown to the minimum treatment elevation of 4578 feet.
- D. Site conditions are variable. Most but not all borings encountered a zone of near surface dense to very dense sand and gravel overlying the site. Historical fill with construction debris was observed in various areas of the site as was detailed in the Geotechnical Investigation Report referenced above. Conditions other than those depicted in the Geotechnical Investigation Report may also be encountered.
- E. The GI Contractor should not advance soil mixing into soil layers that have artesian pressures. It is the GI Contractor's responsibility to account for artesian pressures in design. A Cone Penetration Test report has been included with the above referenced Geotechnical Report, Attachment A.

3.05 EQUIPMENT AND PROCEDURES

- A. Completed columns shall be a uniform mixture of cement and the in-situ soils. Soil and grout shall be mixed in place by the pugmill-type action of the specially designed blades on the mixing shaft. The grout shall be pumped through the mixing shaft and injected from the tip of the shaft. The shaft shall break up the soil and blend it with cement grout. The mixing action of the shaft shall blend, circulate, and knead the soil over the length of the column while mixing it in place with the grout. The quality of the mixing may be evaluated by the Engineer by observing core samples from the verification borings drilled by the GI Contractor.
- B. Flow of grout through the GI equipment during mixing shall be verified before each stroke by observing the flow out of the auger as it is suspended in the air above the GIC. Any blockage in any mixing auger during construction of a GIC shall be cleared immediately upon discovery. If a blockage occurs while mixing a GIC, the blockage shall be cleared,

and the auger shall be raised 10 feet above the depth at which the blockage occurred before recommencing soil mixing.

- C. Once mixing of a GIC is started, continue the mixing operation until the GIC is completed. If an interruption of more than 2 hours occurs during the installation of any GIC, the column shall be remixed for the entire length of the column using the correct dosage of fresh grout, at no additional cost to the Owner, or the GI Contractor shall install additional column next to the un-finished column.
- D. Debris shall not be allowed to enter the top of the GIC while it is curing.
- E. If observations during installation of a GIC indicate a potential for discontinuity of the column due to improper installation procedures, equipment problems or collapse of the surrounding soil, the GIC shall be remixed to full depth, or add another column, at no additional cost to the Owner.

F. Shaft Rotational Speed and Penetration/Withdrawal Rate

The mixing shaft rotational speed (measured in RPMs) and penetration/withdrawal rates may be adjusted to achieve the required mixing. The required blade rotation number and the binder content shall be determined at the beginning of the work and shall be used during the remainder of the work. If these parameters vary by more than 15 percent from those determined during the beginning of the work, the Engineer may require additional testing to help verify acceptable results at no additional cost to the Owner. The blade rotation number and the binder content shall be recorded on the Daily Production/Quality Control Report.

G. Grout Batching and Injection

Dry material shall be stored in silos and fed to mixers for agitation and shearing. To accurately control the mixing ratio of grout, the addition of water and cement shall be determined by a mass flow meter in the circulation line. The dry admixtures, if used, for mixing with water and cement, may be delivered to the mixing plant by a variable speed cement feeding system maintaining mass flow meter accuracy requirements.

- H. The specific gravity of the grout shall be determined during the lab mix program and approved by the Engineer.
- I. Grout shall be pre-mixed in a mixing plant, which combines dry materials and water in predetermined proportions. The mixing plant shall consist of a jet valve, grout circulation pump, variable speed cement feeding system, and a mass flow meter. The mass flow meter shall be used to accurately determine mix proportions in terms of specific gravity.
- J. Proportioning equipment may use meters, weights, or weight-volumes to ensure proper proportions. Progressive cavity pumps shall be used to transfer the grout from the mixing plant to the augers or mixing tools.

- K. The grout injection rate per vertical foot of column shall be in accordance with the requirements of the design mix. The grout injection rate and specific gravity shall be constantly monitored, calculated, and controlled. Additional mixing shall be used when necessary to evenly distribute the grout throughout the entire column to overcome excess or deficient initial grout applications. The volume of the grout injected for each vertical foot of each column shall be monitored, checked by calculation, and recorded on the Daily Production/Quality Control Report by the GI Contractor.

3.06 QUALITY CONTROL

A. General:

1. The GI Quality Control Program shall be the responsibility of the GI Contractor and shall include, as a minimum, the following components: field monitoring during installation and verification strength testing. During the beginning stages of installation, the GI Contractor may decide whether his work yields acceptable results, and he may proceed further with the same methods. The GI Contractor's decision may be based the verification test results for the wet samples and interpolated based on the soilcrete/age curve developed from the lab test program. The Engineer shall use the results of the verification strength tests on the wet and core samples and the acceptance criteria in evaluating the performance of the GI Contractor. The GI Contractor shall provide all the personnel and equipment necessary to implement the Quality Control Program. In addition, the Engineer will observe construction on as needed basis, will perform lab strength tests, and will review GI Contractor submittals to check that the Quality Control Program is being properly implemented.
2. Based on the GI Contractor's evaluation at the beginning stages of the installation, the Quality Control Program may be revised, if agreed to by the Engineer and Owner. The established quality control procedures shall be maintained throughout the production GIC installation to ensure consistency in the GIC construction and to verify that the work complies with all requirements indicated in the plans and specifications.

B. Sample Collection and Strength Testing:

1. The acceptance of the work shall be based on demonstrating that the in-place mixing of grout with the fill soils has achieved the average strength requirements outlined herein. Average strengths shall be determined by testing wet (grab) and core samples collected by the GI Contractor. Confirmation sample collection and testing, other than the testing required by the GI Contractor, may be conducted by the Engineer. Both the Contractor's and the Engineer's testing must demonstrate that the required average strengths are met prior to acceptance of the work. Samples shall be collected by the GI Contractor using wet sampling and continuous core sampling techniques described below. Tests shall be performed at the frequencies described below.

2. Wet (grab) soil mix samples shall be retrieved and cast into molds from one column per shift, at one random depth for each rig each production shift. Samples shall be retrieved using an in situ wet sampler immediately after column construction and shall consist of no fewer than 8 specimens. Soil clods more than 10 percent of the mold diameter shall be screened off. The GI Contractor shall prepare 3-inch by 6-inch cylindrical molded specimens from each wet sample. Appropriate curing techniques shall be implemented until testing. Unconfined compression testing (ASTM D1633) shall be performed by the Engineer at selected ages, including at 56 days for the GIC. The Engineer shall perform unconfined compression testing on the wet and core samples collected from the test and production columns for the treatment zone. The GI Contractor may use the results of specimens tested less than 56 days to provide an early indication of GIC strength and the trend of strength increase with curing time, and to evaluate whether the work can achieve the average strength requirements specified.
3. Continuous core samples shall be retrieved by the GI Contractor from at least one percent production columns and shall be 2.0 inches in diameter (HQ) or larger. Core boring locations shall be selected by the Engineer and flagged by the Contractor's surveyor. Samples shall be retrieved using continuous coring techniques after the soil-grout mixture has hardened sufficiently, i.e., older than 28 days of age and/or the achieving a minimum of 100 psi from associated wet sample testing (or at the discretion of the GI Contractor). The continuous core holes shall extend the entire depth of the soil-grout column. An estimated recovery of 70 percent for each core run and 85 percent for each core hole shall be achieved and each core run shall contain at least one possible test specimen with a length to diameter ratio of at least 2. The GI Contractor may use the down hole image survey to prove the GIC continuity exceeding 85% of the column length. The GI Contractor may select to re-core the same GIC if the initial coring obtained low recovery. If samples are retrieved prior to 56-day strength testing they shall be stored as required to achieve proper curing or, as determined by the GI Contractor, to break the samples earlier. For each core location, four samples selected by the Engineer shall be submitted to an Engineer-approved testing laboratory for unconfined compressive strength testing at 56 days of age. The remainder of the samples recovered shall be submitted to the Engineer for possible inspection and confirmation testing. All core holes shall be grouted after coring. The grout for filling core holes shall have strength equal to or more than that specified for the GIC.
4. Wet coring method, with double pipes inserted into the fresh mixed columns to obtain "core samples", cannot be used as the soil mixing quality evaluation method.
5. GI Contractor shall calculate the average 56-day UCS value from all wet samples and all core samples. A ceiling, not-to-exceed 300 psi shall be used for individual specimens in calculating the average strength achieved in the field from each coring and wet sample and for the entire project. This average 56-day UCS value shall be no less than 150 psi. No more than 10 percent of all specimens tested shall exhibit a UCS of less than 60 psi at 56 days.

6. During the soil mixing production, GI Contractor will review the wet soilcrete strength development and may add additional soil mixing columns if the soilcrete strength is below the target strength. Considering the soil profile and soilcrete strength variation, GI Contractor will set 10 percent of the total soil mixing column as a contingency for additional columns.

C. Consistency of Construction

1. The production GIC s shall be constructed using the same procedures and equipment described in these Specifications and provided by the GI Contractor in the approved design submittals. If procedures and/or equipment used after the beginning stages of production installation are changed by the GI Contractor, the Owner reserves the right to require sampling and testing at the expense of the GI Contractor.

D. Daily Production/Quality Control Report:

1. The Contractor shall submit Daily Production/Quality Control Reports at the end of the next working day. Quality control monitoring during GI construction shall at a minimum include continuous real time monitoring of blade rotation number and the binder content as a function of the depth.
2. The Daily Production/Quality Control Reports shall document the progress on the GI construction. Additionally, the following parameters shall be recorded automatically at intervals not more than 1-foot and the data submitted in the form of either tables or figures, or Excel sheets attached to the Daily Quality Control Report:
 - a. Blade rotation number and vs. depth
 - b. Binder content vs. depth

Contents of the report shall also include all items listed in 1.04.C herein.

3. All strength test results shall be submitted as soon as they become available with the Daily Production/Quality Control Reports; areas treated with GI will not be evaluated by the Engineer until at least one working day following receipt of the applicable Daily Quality Control Report and applicable laboratory test results.

E. Acceptance Criteria:

1. The GI material shall meet all the following acceptance criteria:
 - a. Minimum area replacement ratio of 25 percent for the specified improvement zone and depths.
 - b. The GIC shall be installed within the geometric locations set forth in the approved design, with tolerances provided in 3.02 and 3.03. The depths of the GIC shall be in accordance with 3.01.

- c. The acceptance of the work shall be based on demonstrating that the in-place mixing of grout with the soils has achieved the average strength requirements outlined in the approved design and set forth in 2.03. Average strengths shall be determined by testing wet (grab) and core samples collected by the GI Contractor. The testing must demonstrate that the required average strengths are met prior to acceptance of the work. Wet and core specimens will be tested at 56 days or earlier at the discretion of the GI Contractor. The UCS results from the wet and core samples shall be used in the statistical calculation for the average UCS; however, the ratio of wet sample to core sample UCS test results used to determine the overall average strength in a designated area shall not exceed 1.55.
 - d. Uniformity of mixing shall be evaluated by the Engineer based on the continuous core samples recovered by the GI Contractor. The continuous core-holes shall extend the entire depth of the soil-grout column. An estimated recovery of 70 percent for each core run of a boring and at least 85 percent when averaged over all core runs within a single boring shall be achieved. The GI Contractor may use the down hole image survey to prove the GIC continuity exceeding 85 percent of the column length. Lumps of unimproved soils shall not exceed 20 percent of the total volume of any core run from a boring. Any single unimproved soil section shall not exceed 12 inches. In the fill layer, especially soil containing construction debris and gravels, the unrecovered core length shall be reviewed by the down-hole image survey.
 - e. The Owner may allow the GI Contractor to obtain core samples before the soilcrete achieved 56 days of age. The GI Contractor shall be given the opportunity to conduct additional coring, sampling and strength testing in the failed area.
2. If the acceptance criteria are not achieved, the failed section area shall be rejected. GI Contractor may be given the opportunity to conduct additional coring, sampling and strength testing in the failed area to better define the average design strength at the GI Contractor's expense. Additional core boring locations and sample depths shall be selected by the Engineer. If a designated area is rejected, the GI Contractor shall submit a Remixing or Repair Plan as described 1.04 D for review and approval by the Owner. Remixing or repairs of the failed section areas shall be completed by the GI Contractor at no additional cost to the Owner.

3.07 QUALITY ASSURANCE PROGRAM

A. General:

1. The GI Quality Assurance (QA) Program shall be the responsibility of the Engineer and shall include, as a minimum, the following components: field monitoring during installation and verification strength testing. More specifically, the Engineer shall perform the following tasks as part of the QA program:

- a. Observe and document soil improvement activities at the discretion of the Owner, including primarily observing the soil at the bottom of the predrilled holes,
- b. Select locations of confirmation core borings,
- c. Log confirmation core borings drilled at selected GIC locations,
- d. Review electronic GI outputs in the Daily Production/Quality Control Reports for inconsistencies/issues,
- e. Collect and transport of selected core samples for QA testing,
- f. Complete unconfined compression (UCS) tests at the laboratory on wet and core samples from selected GIC, and
- g. Evaluate whether GIC meet the acceptance criteria in the Specifications. The Engineer shall make the sole determination as to whether the UCS test results indicate that the acceptance criteria have been satisfied. The Engineer will spot check by survey selected GIC locations during construction.

3.08 OBSTRUCTIONS

- A. If obstructions are encountered that prevent advancement of the mixing shaft, the Contractor shall use pre-drilling to penetrate or remove obstructions. If the pre-drill still refuses due to the obstruction, Contractor may consider the following or other remedial options (including jet grouting).
 - 1. If obstruction is shallow, excavate, remove obstruction, and then backfill with engineered fill.
 - 2. Perform additional GIC around the obstruction,
 - 3. Perform jet grouting columns through the obstruction,
- B. If containments in the soil have significant impact on the soil mixing work, Engineer will conduct further investigation and lab tests, and guide the GI Contractor to modify the soil mixing program.
- C. If obstructions are encountered that prevent soil mixing work, include but not limited to, live underground pipes, power lines, and other utilities, the GI Contractor shall modify the soil mixing program and provide to Engineer for approval.

3.09 CONTAINMENT AND COLLECTION OF SPOIL RETURN

- A. Containment

1. Positive means shall be provided for containing all spoil return, flush water, and other waste materials within the work area. Spoil materials should be piped or channeled into holding ponds, tanks, or other retention structures or facilities.
2. Take all necessary precautions and implement measures to prevent any spoil return, waste materials, or stockpiled materials from entering storm drain structures, drainage courses and other utilities, or from leaving the site via surface runoff.

B. Cleaning and Removing

1. In the event spoil return, waste materials, or stockpiled materials enter an area outside of the approved work area or mixing spoils storage area, the Contractor shall be responsible for immediately and completely cleaning and removing these materials to the approval of the Owner at no additional cost to the Owner.

3.10 SITE RESTORATION

- A. Remove the working platform from the GI treatment area and site following acceptance of the stabilization and prior to placement of the foundations as shown on the Contract Drawings.

END OF SECTION

SECTION 31 24 03

GROUND IMPROVEMENT USING AGGREGATE COLUMNS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This specification covers the following items of work:
1. Furnishing all labor, supervision, equipment, and materials necessary to perform aggregate column (AC) performance-based design, test section and install production ACs within the improvement zones and depths as shown on the Contract Drawings and in this Specification with all associated acceptance testing, monitoring, sampling, recording, and site restoration and provide all associated documentation.
 2. Evaluate site conditions and data provided and perform any additional investigation, testing or analysis materials necessary to complete the design and a compliant installation.
 3. Deliver and place all materials necessary in the improvement process.
 4. Collect, store, and dispose of all spoils and water produced by the installation process, including groundwater that may rise to the surface during installation.
 5. Monitor and mitigate impacts of the ground improvement operation on existing utilities, roadways and nearby structures, including, but not limited to potential vibrations, settlement, heave and coordination with other site activities.
 6. Perform and document post installation testing to verify the required level of improvement.

1.02 DEFINITIONS

- A. Contractor – refers to the general contractor for the Project.
- B. Ground Improvement (GI): Treating soil in situ by installing aggregate columns.
- C. Aggregate Columns (AC): columns of compacted aggregate which also densify the surrounding soil; either rammed aggregate piers installed in the ground by drilling an open or cased hole, introducing aggregate and compacting by tamping in lifts, or stone columns installed by the bottom-feed vibro-replacement method, compacting by vibrating the stone injected as a large vibratory probe is moved up and down while progressively withdrawn from the column bottom to the ground surface.
- D. GI Contractor – refers to the subcontracted ground improvement contractor for the Project.

- E. Spoils: All materials including liquids, semi-solids, and solids that are discharged above ground surface during, or as a result of, GI operations.
- F. Quality Control Testing Laboratory (Lab): An independent testing laboratory retained by the Contractor that is responsible for obtaining and testing specimens for quality control.
- G. Working Platform Level: The ground surface level from which the AC are installed.
- H. Pre-Drilling: Performed up to an equivalent diameter, up to the design depth to move soil and reduce penetration resistance or remove obstructions.
- I. Water Jetting: The use of water jets emitted from the bottom tip of the vibrator during column installation or vibrator penetration.
- J. Lift: The height of stone column that is constructed with the stone from one hopper load.
- K. Power Consumption: The amount of effort expended by the vibratory probe (electric or hydraulic) during stone column construction.
- L. Amperage: The strength of electric current expressed in amperes. During stone column construction, the measurement of amperage (from the generators powering an electric vibrator) is a measure of the power consumption of the vibrator.

1.03 GROUND IMPROVEMENT DESIGN

- A. The GI Contractor shall design patterns based on AC technology to satisfy requirements for the treatment zone specified herein. Ground Improvement Design submittal shall include a Quality Control Plan confirming required acceptance criteria which shall be submitted to the Engineer for review and approval.
- B. This specification is for installation of soil mix columns. Alternate bids using Soil Mix Columns, Section 31 24 02, will be considered.
- C. Use a qualified, registered professional engineer experienced in GI to design AC including column size and layout and provide supporting calculations.
- D. Design requirements include, but are not limited to, the analysis to conform the AC treatment adequately satisfies Project performance criteria. The GI Contractor shall obtain adequate samples, perform aggregate tests, and determine the final gradation mix compliant with the specifications and the AC design and installation parameters.
- E. Performance criteria documented by the design analysis shall provide the following ground control for foundation support of all structures in the mitigation area:
 - 1. A minimum area replacement ratio of 0.25. The GI Contractor may include an alternative providing a line item deduct for consideration by the Owner using a lower area replacement ratio if accompanied by supporting design and calculations

or modeling (sealed by a Utah registered professional engineer) demonstrating conformance to other performance criteria below.

2. A minimum bearing capacity of 6,000 pounds per square foot.
3. Mitigation of static settlement to less than one inch.
4. Mitigation of seismic shaking and liquefaction settlement to less than three inches, using the 2021 method of analysis for silts where applicable. (ref. Bray, Shao et al.)

F. Site Preparation by the Contractor:

1. The building pads identified on the drawings will be over-excavated to the elevation shown on the Contract Drawings. The Contractor will provide GI Contractor a flat, dry, stable working platform, suitable for the soil mixing equipment operation.

G. Contract Work Includes:

1. In accordance with the specifications contained in this Section and as shown on the plans, the GI Contractor shall furnish all plant, equipment, labor, and materials required to construct all the AC as indicated in the Contract Documents.
2. The GI Contractor shall determine and be responsible for providing all mixing binder material.
3. Construct AC in area shown on the plans.
4. Implement the Quality Control Plan and provide all submittals and documentation as required in these specifications, include, but are not limited to monitor the tool penetration depth, rate etc., provide daily production and QC reports, provide remixing or repair plans as needed, collect aggregate samples every shift and transport the samples to Lab for gradation and soundness testing, drill confirmation core holes at randomly selected locations.

H. Owners Representative

The Owner's Quality Assurance (QA) representative Engineer for the Provo River Water Treatment Plant project (Project) will be AECOM. They will perform the following the following tasks:

1. Observe and document soil improvement activities,
2. Log confirmation core borings drilled at selected AC locations,
3. Select locations of confirmation test locations,
4. Accept and transport samples to an accredited laboratory to cure samples to the planned test dates,

5. Oversee aggregate tests performed by the Lab on selected wet and core samples and evaluate the test results,
6. Prepare a final report that will include a summary of field observations, laboratory test data and an opinion as to whether the AC meet the acceptance criteria. The final inspection report will be submitted to the Owner for review and approval.

1.04 REFERENCES

A. Standards

1. ASTM C33: Specification for Concrete Aggregates
2. ASTM C131: Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
3. ASTM D1143: Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.
4. ASTM D1586: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
5. ASTM D5778: Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.
6. ASTM D1586: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
7. ASTM D5778: Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.

B. References

1. Geotechnical Report, Attachment A: provided for information purposes only. GI Contractor shall base their design on their own assessment of site geotechnical conditions and proposed foundation system.
2. Applicable Project Drawings including improvement area plan and underground utilities plan.
3. Contract Documents
4. EERI, 2010. Liquefaction Monograph

1.05 SUBMITTALS

Prepare and submit to the Engineer a work plan including:

A. Qualifications

1. The qualifications of a registered Professional Engineer licensed in the state of Utah to design, and of a GI Contractor to perform, the ground improvement, each with a minimum 5-years of experience. Document five recent, successful projects completed with site conditions and improvement criteria similar to this project.

B. Design Performance

1. A ground improvement design including calculations prepared and stamped by the qualified, Professional Engineer, based on information contained in the project geotechnical report, prepared by the engineer licensed in the state of the work to be performed that demonstrates that the program achieves the performance criteria in these specifications.
2. The design shall include Ground Improvement drawings signed and sealed by the registered Professional Engineer, depicting the spacing and approximate depth at each AC location. Show on the drawings the location of the ACs with respect to the structure footprint and footings. The Contractor is responsible for providing all lines and grades for the ACs, including locations of all utilities and survey markers.
3. Use a square or equilateral triangular grid pattern that will provide the required improvement in the soils, meeting the following minimum criteria:
 - a. The zones of soil to be improved shown in the drawings, both vertical and lateral limits.
 - b. For each structure provide a minimum factor of safety of 2.5 for bearing capacity.
 - c. The design should consider the impacts of loads or fills adjacent to structures. Grading by the GI Contractor is expected to be minimal.
 - d. The GI Contractor should provide all testing and analysis to verify the design parameters used in the mitigate analysis are appropriate.
 - e. The Contractor should verify improvement by using the Standard Penetration Test (SPT), Cone Penetrometer Test (CPT) or another method accepted by the Engineer at a minimum of one test per 3000 square feet of improved footprint, evenly distributed across each structure. If the SPT is used, conduct tests at depth intervals of two feet (i.e., 6 inches between each 18-inch sample).
 - f. Where the bearing capacity controls the column spacing, unless an alternate test method is accepted in advance by the Owner, conduct load tests on at least one column per 5000 square feet of structure, one per building, and a minimum of two tests in total, using the procedures of ASTM D1143 to determine the modulus of the columns. Tests should be performed in locations selected by the Engineer following production installation.
 - g. Identify the load-deflection criteria to be verified by the tests.

- h. Preproduction test columns and reaction piles/columns not meeting the design mitigation criteria should be considered sacrificial unless additional columns are added, and retesting shows the criteria are met.
 - i. Additional test column locations should be approved by the Engineer.
- 4. Installation methods for preproduction test columns should be identical to installation methods for production columns.
- 5. Place a layer of compacted structural fill at least 24 inches in thickness beneath each structure to help provide uniform foundation support and distribute loads across the AC system. Structural fill should be 3-inch minus Granular Backfill Borrow. Where fine grained soils are encountered, place a stabilization-separation geotextile at the base of the structural fill.
- 6. Footing Subgrade Preparation (by others)

The footing base shall be free of all water and compacted prior to placement of any reinforcement. Compaction can be by any heavy tamping type compaction equipment designed for compaction in small spaces. Reinforcement and concrete placement shall be placed in a timely manner so that no degradation of the bearing surface occurs.
- C. A ground improvement QA plan, as detailed in Section 3.6 of these specifications.
- D. Proposed monitoring and mitigations for existing building or facilities.
- E. Resumes of the management, supervisory, and key personnel.
- F. A description of the proposed construction process. Including:
 - 1. A detailed written procedure to be followed to improve the soils through installation of the ACs.
 - 2. Describe the equipment to be used.
 - 3. Describe the proposed documentation, and submittal frequency proposed to document aggregate quantities, density and diameters of the installed columns.
 - 4. Test data on the stone to be used for constructing the ACs that demonstrates the stone backfill conforms to the material specifications provided herein.
- G. Submit to the Engineer the GI Contractor's signed certification and installation quantity and vibration data for each column, as required by this specification.
- H. Prior to demobilization of the GI Contractor from the site, the Contractor must submit documentation to the Owner indicating that the acceptance criteria outlined in this specification have been met and approved by the Engineer.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Use stone backfill consisting of Grade A 57 clean, hard, durable crushed rock, free of organic matter and other deleterious substances. Test stone in accordance with ASTM C131 and demonstrate a maximum loss of 40 percent or less. Provide stone meeting the following gradation:

Table 1: Recommended Stone Gradation	
Sieve Size	Percent Passing (by weight)
1 ½ inch	100
1 inch	90-100
½ inch	5-80
No. 40	0-5

2.02 EQUIPMENT – SEE SECTION 3.5

- A. Vibratory Probe
- B. Vibratory Casing Hammer
- C. Load Test Equipment

PART 3 - EXECUTION

3.01 GENERAL

- A. Arrange for a qualified representative of the GI Contractor to be onsite, directly involved and provide technical assistance during all phases of the AC installations. A qualified representative is defined as a person with a minimum of five years of experience with similar AC installations.
- B. Install and document all in accordance with foundation improvement plans, this specification, and the GI Contractor's work plan.
- C. Provide assurance that the completed installations meet all Project specifications. Where this specification and the specifications of the GI Contractor differ, the stricter of the two shall control.
- D. Provide quality control of the construction of ACs.
- E. Report any non-conformance or other irregularity to the Engineer within one working day of observing the irregularity.

- F. Stake the AC locations to within 2 inches to avoid conflicts with utilities and other Project features.

3.02 HORIZONTAL ALIGNMENT

- A. The GI Contractor will accurately stake the locations of the proposed AC shown on the plans before installation. Selected locations will be verified by a surveyor provided by the Owner. The columns shall be constructed within a tolerable distance from the plan location. Tolerable deviation shall be stated on the plan.
- B. Beneath the footings of the structures for the layout detail on the plans the AC shall be configured to provide consistent footing support.
- C. Movement of the crawler base machine shall provide the preliminary alignment of the AC locations and the final alignment shall be adjusted by hydraulic manipulation of the leads. The AC shall be advanced stepwise where applicable.

3.03 VERTICAL ALIGNMENT

- A. Vertical alignment of the columns shall be controlled by the equipment operator. Two measurements of vertical shall be monitored, the forward-aft and left-right. The AC shall be installed at an average inclination deviating no more than two percent from vertical.

3.04 COLUMN DEPTH

- A. The anticipated AC depth at each column location shall be determined by the depth elevations shown on the plans. Columns shall be terminated either at the contour elevations shown on the plans, or at a depth revised by the GI Contractor, whichever is deeper. In no case shall the columns be terminated at an elevation higher than the contours shown on the plans. In the field, the GI Contractor shall determine the actual depth of each column, based on the soil conditions and obstacles.
- B. The GI Contractor is responsible for penetrating any unexcavated soil, including any materials overlying the designated treatment zone, in order to reach the bottom of the treatment zone. This includes, as necessary – excavation, predrilling, use of an advance, etc., in order to penetrate the treatment zone as shown to the minimum treatment elevation on the plans.
- C. Site conditions are variable. Most, but not all, borings encountered a zone of near surface dense to very dense sand and gravel overlying the site. Historical fill with construction debris was observed in various areas of the site as was detailed in the Geotechnical Report, Attachment A, referenced above. Conditions other than those depicted in the Geotechnical Report could also be encountered.
- D. The GI Contractor should not advance ACs into soil layers that have artesian pressures. It is the GI Contractor's responsibility to account for artesian pressures in design. A Cone Penetration Test report has been included in the Geotechnical Report, Attachment A.

- E. Additional soils testing may be performed by the Contractor at the Contractor's expense.

3.05 EQUIPMENT & PROCEDURES

- A. The GI Contractor shall determine the construction procedures and the specific equipment to be used to achieve the design criteria specified below; however, the following general equipment and construction procedure requirements should be met:
 - 1. A rammed aggregate pier or dry bottom-feed vibro-replacement method shall be used.
 - 2. Water or air jets to aid the advance of the vibrator, follower tubes and tremie system, or to otherwise assist with the installation of the columns may not be used, unless specifically approved by the Engineer.
 - 3. ACs shall be backfilled above the designated treatment zone by extending the AC through the overlying soils to subgrade level of the structure, using the same dry bottom-feed method and the same compaction and quantity criteria that were used in the treatment zone.
 - 4. Rammed ACs
 - a. All AC elements shall be pre-augered using mechanical drilling or excavation equipment.
 - b. Installation of AC without pre-augering shall not be allowed because this technique results in significant disturbance and remolding of the matrix soils surrounding the columns.
 - c. If cave-ins occur during excavation such that the sidewalls of the hole are deemed to be unstable, steel casing or a drilling slurry shall be used to stabilize the excavation. If cave-ins occur on top of a lift of aggregate such that the volume of the caved soils is more than 10 percent of the volume of the aggregate in the lift, then the aggregate shall be considered contaminated and shall be removed and replaced with uncontaminated aggregate.
 - d. Special high-energy impact densification apparatus shall be employed to densify the AC elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate. A minimum tamper energy level of 250,000 foot-pounds of force per minute shall be applied by the apparatus.
 - e. The bottom of the excavation shall be densified prior to the placement of the aggregate. If wet, soft or sensitive soils are present, open-graded aggregate, such as ASTM No. 57 stone or other, shall be placed at the bottom of the excavation and compacted to stabilize the element bottom and may serve as the initial lift. Densification shall be performed using a beveled tamper. The beveled tamper foot is required to adequately increase the lateral earth

pressure in the matrix soil during installation. Downward pressure shall be applied to the tamper shaft during tamping. Each lift of aggregate shall be tamped for a minimum of 15 seconds.

5. Vibroreplacement:

- a. Provide a down hole vibratory probe producing horizontal vibrations from an energy source located near the tip of the probe. The GI Contractor shall use an electric vibrator capable of providing at least 80 HP of rated energy and a centrifugal force of 15 tons. An appropriate metering device should be provided at such a location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the vibrator. The vibrator shall be a minimum of 16 inches in diameter and be capable of creating stone columns with diameters up to 36 inches. A crane or crawler base rig shall be provided, compatibly to operate the probe. Complete equipment specifications should be submitted to the Engineer prior to commencement of the fieldwork.
- b. Install AC with a down-hole vibrator capable of densifying the aggregate by forcing it radially into the surrounding soil. The vibrator shall be of sufficient size and capacity to construct AC to the diameters and lengths shown on the installer's approved construction drawings.
- c. The probe and follower tubes shall be of sufficient length to reach the elevations shown on the installer's approved construction drawings. The probe, used in combination with the available pressure to the tip jet, shall be capable of penetration to the required tip elevation. Pre-boring shall be permitted if it is specified in the installer's approved construction procedure submittal.
- d. The probe and follower shall have visible markings at regular increments to enable measurement of penetration and re-penetration depths.
- e. Provide methods for supplying to the tip of the probe enough air or water to widen the probe hole to allow adequate space for stone backfill placement around the probe.
- f. The probe shall penetrate into the foundation soil layer to the minimum depths required in the installer's construction plans.
- g. Lift thickness shall not exceed four feet. After penetration to the treatment depth, slowly retrieve the vibrator in 12-inch to 18-inch increments, allowing for backfill placement.

3.06 QUALITY CONTROL

A. Documentation

Submit any proposed change in the approved construction program in writing to the Engineer.

Submit daily to the Engineer: a log including.

1. Accurate daily records that include column numbers, depth of treatment, approximate backfill quantities for each column, and recordings of ground resistance (e.g., amperage or hammer energy) readings the type and size of compaction equipment and predrill auger diameter used (when needed), and a shop drawing indicating the as-constructed location. The daily logs must demonstrate that the column installation and performance across the site are consistent with the design and performance achieved in the tested columns.
2. A record for each AC that includes a log of the aggregate consumption per 5-foot maximum increment, energy used to compact the column per 5-foot maximum increment, column identification number, bottom depth, column length, time to construct the column, and a note of any obstructions or other problems encountered during column installation.
3. Any change in the subsurface conditions observed during the work.

B. Testing

1. Penetrometer Testing: standard penetration test (SPT) or cone penetration test (CPT), if appropriate for soil conditions and if specified.

All testing to determine specification compliance will be provided by the Contractor, and will consist of Penetration Testing and on-site observation by the Engineer during the AC installation.

- a. SPT/CPT testing shall be performed at locations which are equidistant and farthest from two, three, or four probes, whichever is applicable, with a multiple probe pattern under a column or wall footing.
 - b. The work shall consider an averaging of SPT/CPT values for the test hole, and also the location of the test hole within the treated area.
 - c. Areas of the site not adequately densified as determined by the specified SPT/CPT values shall be recompactd by installing additional AC at no additional cost to the Owner.
 - d. The Engineer will provide site inspection to insure proper performance of the AC. This inspection may include the following: observance of the AC Contractor's procedures, recording of backfill quantities, and recording of ammeter information.
2. Static Load Testing (if specified)

Testing to determine specification compliance will be provided by the Contractor, and will consist of a full-scale Static Load Test (Section 1.03.A.1).

- a. The load test shall be performed at an actual foundation location chosen by the Engineer. The foundation area to be tested should be a minimum 5-foot diameter plate.
- b. The load test shall be erected and performed by the Contractor at the Contractor's expense.
- c. The load test shall be performed in general accordance with ASTM D1143 Quick Test. The test foundation shall be loaded to 1.5 times the design load of 6,000 psf. Settlements of the test foundation shall be measured halfway between the center and each of the four corners. The average of the four readings shall be used to confirm acceptance of the required settlement criteria. The contractor shall submit load test detail and prior to load testing.
- d. The QC representative will provide site inspection to insure proper performance of the AC work. This inspection may include the following: observance of the AC Contractor's procedures, recording of backfill quantities, and recording of ammeter information.
- e. If uplift elements are used to develop the reaction load for the load test, they shall develop their uplift capacity below the depth being improved by the AC or located horizontally at least 10 feet away from the edge of the load test footing columns.

C. Consistency of Construction

1. The production ACs shall be constructed using the same procedures and equipment described in these Specifications and provided by the GI Contractor in the approved design submittals. If procedures and/or equipment used after the beginning stages of production installation are changed, the Owner reserves the right to require additional sampling and testing at the expense of the Contractor.

D. Daily Production/Quality Control Report:

1. The GI Contractor shall submit Daily Production/Quality Control Reports at the end of the next working day. Quality control monitoring during AC construction shall at a minimum include continuous real time monitoring of aggregate quantity and the binder content as a function of depth.
2. The Daily Production/Quality Control Reports shall document the progress on the AC construction. Additionally, the following parameters shall be recorded automatically at no less than 1 foot interval and the data submitted in the form of either tables or figures, or Excel sheets attached to the Daily Quality Control Report:
 - a. Column number and depth

- b. Aggregate consumption with depth
- 3. All QC test results shall be submitted as soon as they become available with the Daily Production/Quality Control Reports; areas treated with AC will not be evaluated by the Engineer until at least one working day following receipt of the applicable Daily Quality Control Report and applicable laboratory test results.

E. Acceptance Criteria:

- 1. The AC treated zone shall meet all of the following acceptance criteria:
 - a. The AC shall be installed within the geometric tolerances, area and depths specified herein.
 - b. The acceptance of the work shall be based on demonstrating that AC treatment matrix of improved ground has achieved the average strength requirements outlined herein. Average strengths shall be determined by composite strength analysis methods. The testing must demonstrate that the required average strengths are met prior to acceptance of the work.
 - c. Uniformity of work shall be evaluated by the Engineer based on the production logs of the GI Contractor.
 - d. If the acceptance criteria are not achieved, the failed area shall be rejected. The Contractor may be given the opportunity to conduct additional testing in the failed area to better define the average design strength at the Contractor's expense. Additional test locations and depths shall be selected by the Engineer. If a designated area is rejected, the Contractor shall submit a Remedial Plan as described herein for review and approval by the Owner. Remedial work of failed section areas shall be completed by the GI Contractor at no additional cost to the Owner.

3.07 QUALITY ASSURANCE PROGRAM

A. General:

- 1. The GI Quality Assurance (QA) Program shall be the responsibility of the Engineer and shall include, as a minimum, the following components: field monitoring during installation and verification strength testing. More specifically, the Engineer shall perform the following tasks as part of the QA program:
 - a. Field monitoring during installation and verification testing, recording observed results.
 - b. Observe and document soil improvement activities at the discretion of the Owner, including primarily observing the soil at the bottom of the predrilled holes.

- c. Notify the GI Contractor if the soil at the bottom of a predrilled hole is not the targeted, dense, competent materials.
- d. Review electronic GI outputs in the Daily Production/Quality Control Reports for inconsistencies/issues.
- e. Review Lab test data
- f. Evaluate whether AC meet the acceptance criteria in the specifications. The Engineer shall make the sole determination as to whether the acceptance criteria have been satisfied. The Engineer will spot check by survey selected AC locations during construction.

3.08 OBSTRUCTIONS

- A. If obstructions are encountered that prevent advancement of the mixing shaft, the Contractor shall use pre-drilling to penetrate or remove obstructions. If the pre-drill still refused due to the obstruction, Contractor may consider the following or other remedial options (such as jet grouting).
 - 1. If an obstruction is shallow, excavate then remove obstruction and then backfill with engineered fill.
 - 2. Perform additional AC around the obstruction.
- B. If contaminants in the soil have significant impact on the GI work, Engineer will conduct further investigation and lab tests, and guide the GI Contractor to modify the program.
- C. If obstructions are encountered that prevent AC work, include but not limited to, live underground pipes, power lines, and other utilities, the GI Contractor shall modify the program and provide to Engineer for approval.

3.09 CONTAINMENT AND COLLECTION OF SPOIL RETURN

- A. Containment
 - 1. Positive means shall be provided for containing all spoil return, flush water, and other waste materials within the work area. Spoil materials shall be piped or channeled into holding ponds, tanks, or other retention structures or facilities.
 - 2. Take all necessary precautions and implement measures to prevent any spoil return, waste materials, or stockpiled materials from entering storm drain structures, drainage courses and other utilities, or from leaving the site via surface runoff.
- B. Cleaning and Removing
 - 1. In the event spoil return, waste materials, or stockpiled materials enter an area outside of the approved work area or spoils storage area, the Contractor shall be

responsible for immediately and completely cleaning and removing these materials to the approval of the Owner at no additional cost to the Owner.

3.10 RESTRICTIONS

- A. AC construction is typically performed under the site permit. The Contractor shall be responsible for obtaining any state and local permits (if required) and conforming to all state and local regulations.
- B. The Contractor will be responsible for the precise delineation of all above and below ground utilities and obstructions.
- C. The following shall also be listed within this section when applicable:
 - 1. Environmental restrictions.
 - 2. Work boundaries.
 - 3. Hours for construction.

END OF SECTION

SECTION 31 50 00

EXCAVATION SUPPORT SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide excavation support systems as indicated and in compliance with Contract Documents.
- B. Design, furnish and install excavation support systems to maintain lateral support, prevent loss of ground, limit soil movements to acceptable limits and protect from damage existing and proposed improvements including pipelines, utilities, structures, roadways, railroads and other facilities.
- C. The requirement of specified excavation support systems in areas indicated on the drawings does not relieve the Contractor from the responsibility of furnishing and installing proper temporary excavation support systems in other areas.
- D. Common types of excavation support system include, but are not limited to; singular or multiple stages comprised of cantilevered or internally braced soldier piles and lagging, steel sheetpile wall, timber sheetpile wall, trench box, or combinations thereof. Trench box temporary excavation support system is only acceptable for pipe or utility trench excavations approved by the Engineer. Temporary unsupported open cut excavation with stable sloping sides is allowed where applicable.
- E. Extraction of steel sheetpile wall, timber sheetpile wall, or soldier piles are not permitted unless otherwise indicated, specified or approved by the Engineer.
- F. Wherever the word "sheeting" is used in this section or on the contract drawings, it shall be in reference to any type of excavation support system specified except trench box.
- G. Construction of the excavation support systems shall not disturb the existing structures or the completed proposed structures. Damage to such structures shall be repaired at Contractor's expense.
- H. Adjacent structures are those that are bear upon soils above the proposed excavation depth and within a distance equal to twice the total depth of the excavation away from the closest edge of the excavation. Monitor and protect adjacent structures as specified and indicated.
- I. Vibration monitoring for excavation support systems shall be performed as specified in Section 02 32 14.
- J. Construction operations not to exceed specified noise limits in permits.

- K. Bear the entire cost and responsibility of correcting any failure, damages, subsidence, upheaval or cave-ins as a result of improper installation, maintenance or design of the excavation support systems. Pay for all claims, costs and damages that arise as a result of the Work performed at Contractor's expense.

1.02 REFERENCES:

A. American Concrete Institute (ACI):

- 1. 304: Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.

B. ASTM International (ASTM):

- 1. A36: Standard Specification for Structural Steel.
- 2. A416: Standard Specification for Strand Steel, Uncoated Seven Wire for Prestressed Concrete.
- 3. A572: Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel.
- 4. A615: Standard Specifications for Deformed and Plain Billet Steel Bars for Concrete Reinforcement
- 5. A722: Specification for Uncoated High Strength Steel Bar for Prestressing Concrete

C. American Wood-Preserves Association (AWPA) Standards.

- 1. P23-10: Standard for Chromated Copper Arsenate Type C (CCA-C).
- 2. P50-10: Standard for Fire Retardant FR-2 (FR-2).

D. American Welding Society (AWS)

- 1. D1.1: Structural Welding Code.

E. Occupational Safety and Health Administration (OSHA) Standards and Regulations contained in Title 29: Subpart P - Excavations, Trenching and Shoring.

1.03 SUBMITTALS

A. Submit the following in accordance with Section 01 33 00.

- 1. Submit the following qualifications four weeks prior to the construction:
 - a. Qualifications of Contractor's excavation support system designer as specified in Paragraph 1.04.G.

- b. Qualifications of Contractor's excavation support system installer as specified in Paragraph 1.04.H.
 - c. Qualifications of Contractor's independent tieback testing laboratory as specified in Paragraph 1.04.I, if a tieback system is utilized.
 - d. Qualifications of Contractor's excavation support system installation supervisor as specified in Paragraph 1.04.J.
 - e. Qualifications of vacuum excavation subcontractor as specified in Paragraph 1.04.F, if DMPs for utilities are utilized.
2. Submit an excavation support plan stamped and signed by a Registered Professional Engineer in the State of Utah at least two weeks prior to start of the construction. Do not submit design calculations. The review will be only for the information of the Owner and third parties for an overall understanding of the project relating to access, maintenance of existing facilities and proper utilization of the site. The Contractor remains responsible for the adequacy and safety of the means, methods and sequencing of construction. The plan shall include the following items as a minimum:
- a. Proposed excavation support system(s), details, location, layout, depths, extent of different types of support relative to existing features and the permanent structures to be constructed, and methods and sequence of installation and removal.
 - b. Certificate of Design: Refer to Section 01 33 00.
 - c. A list of all design assumptions, including safety factors used for the excavation support system(s) and all lateral pressures used for each system.
 - d. If utilizing a tieback system, include tieback installation procedures and criteria for acceptance of tiebacks for performance and proof tests. Submit the tieback testing results to the Engineer for information only.
 - e. Requirements of dewatering during the construction.
 - f. Minimum lateral distance from the edge of the excavation support system for use for vehicles, construction equipment, and stockpiled construction and excavated materials.
 - g. List of equipment used for installing the excavation support systems.
 - h. Monitoring schedule, installation procedures and location plans for vibration/noise monitoring, geotechnical instrumentation (deformation monitoring points and inclinometers) and observation wells/piezometers to monitor ground, excavation support system, adjacent structures and groundwater fluctuation during the entire construction period.

3. Submit a Construction Contingency Plan specifying the methods and procedures to maintain excavation support system stability if the allowable movement of the adjacent ground and adjacent structures is exceeded. Include movement thresholds that trigger review and/or remediation measures to be implemented.
4. Monitoring data within one day of data collection from vibration and noise recording equipment, observation wells, deformation monitoring points and offset lines. Data shall include:
 - a. Horizontal and vertical movements of geotechnical instruments and groundwater readings.
 - b. New movements since the initial readings of the geotechnical instruments.
 - c. Weekly summary in tabular and graphic form at the end of each week.
 - d. A schematic plan of excavation and/or relevant construction activities at the time of monitoring.
5. For excavation support systems left in place, submit the following as-built information prior to backfilling and covering the excavation support systems:
 - a. Survey locations of the excavation support systems, including coordinates of the ends and points of change in direction.
 - b. Type of the excavation support system.
 - c. Elevations of top and bottom of the excavation support systems left in place.

1.04 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 45 00.
- B. Conform to the requirements of the OSHA Standards and Interpretations: "Part 1926 Subpart P - Excavation, Trenching, and Shoring".
- C. Construction operations to conform to noise regulations provided in the Noise Control Plan and this Section.
- D. Retain the services of an independent vibration consulting firm meeting the requirements as specified in Section 02 32 14.
- E. The peak particle velocity for pile driving, or other vibration-inducing operations, shall meet the requirements as specified in Section 02 32 14.
- F. If utilizing deformation monitoring points (DMPs) for utilities, vacuum excavation shall be performed by subcontractor having five years of experience in non-destructive vacuum excavation methods for utilities.

- G. Prepare design, including calculations and drawings, under the direction of a Professional Engineer registered in the State of Utah and having the following qualifications:
 - 1. Not less than ten years of experience in the design of specific excavation support systems to be used.
 - 2. Completed not less than five successful excavation support system projects of equal type, size, and complexity within the last five years.
- H. Excavation Support System Installer's Qualifications:
 - 1. Not less than three years of experience in the installation of similar types and equal complexity as the proposed system.
 - 2. Completed not less than three successful excavation support systems of similar type and equal complexity as the proposed system.
- I. If utilizing a tieback system, employ an independent testing laboratory to test the tieback system with the following qualifications:
 - 1. Be accredited by the American Association of State Highway and Transportation Officials (AASHTO) Accreditation Program.
 - 2. Employ personnel conducting testing who are trained in the methods and procedures to test and monitor tieback systems of similar type and equal complexity, as the proposed system.
 - 3. Have not less than five years of experience in testing of tieback systems of similar type and equal complexity as the proposed system.
 - 4. Have successfully tested at least three tieback systems of similar type and equal complexity as the proposed system.
- J. Install all excavation support systems under the supervision of a supervisor having the following qualifications:
 - 1. Not less than five years of experience in installation of systems of similar type and equal complexity as the proposed system.
 - 2. Completed at least five successful excavation support systems of similar type and equal complexity as the proposed system.
- K. All welding shall be performed in accordance with AWS D1.1.

1.05 DESIGN CRITERIA:

- A. Design of excavation support systems shall meet the following minimum requirements:
1. Support systems shall be designed for earth pressures, hydrostatic pressure, equipment, temporary stockpiles, construction loads, roadways, railroads, and other surcharge loads.
 2. Design a bracing system to provide sufficient reaction to maintain stability.
 3. Limit movement of ground adjacent to the excavation support system to be within the allowable ground deformation as specified.
 4. Design the embedment depth below bottom of excavation to minimize lateral and vertical earth movements and provide bottom stability. Toe of braced temporary excavation support systems shall not be less than 5 feet below the bottom of the excavation.
 5. Design excavation support systems to withstand an additional 2 feet of excavation below proposed bottom of excavation without redesign except for the addition of lagging and/or bracing.
 6. Maximum width of pipe trench excavation shall be as indicated on the drawings.
 7. Do not cast permanent structure walls directly against excavation support walls.
 8. The design location of the excavation support wall shall be determined such that the installed wall and bracing system components are all located outside the limits of the permanent structure. Construction tolerances (e.g. wall verticality) shall be considered in determining the plan location.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Provide in accordance with APWA Sections 01 66 00 and as specified.
- B. Store sheeting and bracing materials to prevent sagging which would produce permanent deformation. Keep concentrated loads which occur during stacking or lifting below the level which would produce permanent deformation of the material.

1.07 PROJECT CONDITIONS:

- A. Subsurface Conditions: Refer to Section 00 21 13.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Structural Steel: All soldier piles, wales, rakers, struts, wedges, plates, waterstop and accessory steel shapes shall conform to ASTM A36.
- B. Steel Sheet Piling: ASTM A572, continuous interlocking type.
- C. Timber Lagging Left in Place: Pressured treated per AWP standards.
- D. Tieback Tendons: Tieback tendons shall be high strength steel wire strand cables conforming to ASTM A416, or bars conforming to ASTM A722. Splicing of individual cables shall not be permitted.
- E. Raker Ties: ASTM A615 Grade 60.
- F. Cement Grout Materials and Admixtures For Tieback Anchorages: Grout cube strength shall be a minimum 3500 psi at 7 days and 5000 psi at 28 days.
- G. Concrete: Section 03 30 00.
- H. Tamping tools adapted for backfilling voids after removal of the excavation support system.
- I. Provide specific trench box sizes for each pipe and utility excavation with structural capacity of retaining soil types as described in OSHA's 29 CFR Part 1926 Subpart P.

2.02 EQUIPMENT:

- A. Install shoring to required depth with suitable equipment for installation of shoring materials. Equipment can include vibratory hammers, impact hammers, hydraulic push-in tools, drills or other equipment that meets vibration and noise requirements.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Installation of the excavation support systems shall not commence until the related earth excavation and dewatering submittals have been reviewed by the Engineer with all Engineer's comments satisfactorily addressed.
- B. Install excavation support systems in accordance with the excavation support plan.
- C. If utilizing a tieback system, all performance and proof tests shall be conducted in the presence of the Engineer. Testing performed without the Engineer present is considered invalid. Repeat testing in the Engineer's presence at Contractor's expense.

- D. Do not drive sheeting within 100 feet (30 m) of concrete less than seven days old.
- E. Carry out program of excavation support in such a manner as to prevent undermining or disturbing foundations of existing structures of Work ongoing or previously completed.
- F. Bottom of the trench box excavation support system shall be above the pipe invert prior to installing the pipe.
- G. Install and read geotechnical instrumentation in accordance with the excavation support plan. Notify the Engineer immediately if any geotechnical instrumentation is damaged. Repair or replace damaged geotechnical instrumentation at the sole option of the Engineer and at Contractor's expense.
- H. Continuously monitor movements of the ground adjacent to excavation support systems and adjacent structures. In events of the measured movements approaching or exceeding the allowable movements, take immediate steps to arrest further movement by revising procedures such as providing supplementary bracing, filling voids behind the trench box, supporting utilities or other measures (Construction Contingency Plan).
- I. Notify utility owners if existing utilities interfere with the excavation support system. Modify the existing utility with the utility owner's permission or have the utility owner make the modifications at Contractor's expense.

3.02 GROUND DEFORMATION ADJACENT TO EXCAVATION SUPPORT SYSTEMS:

- A. Allowable Vertical (heave/settlement) and Lateral Movements: Two inches maximum for the trench box excavation support system, and one inch maximum for other types of excavation support systems at any location behind the excavation support system.
- B. Monitoring personnel shall use a procedure for reading and recording geotechnical instrumentation data which compares the current reading to the last reading during data collection to eliminate spurious readings.
- C. Plot the observed ground deformation readings versus time. Annotate the plots with construction loading and excavation events having an impact on the readings. Evaluate plots by means of secondary rate-of-change plots to provide early warning of accelerating ground movements.
- D. Notify the Engineer when the allowable ground deformation is exceeded.
- E. Implement Construction Contingency Plan under direction of the temporary excavation support system designer and the Engineer.

3.03 REMOVAL OF EXCAVATION SUPPORT SYSTEMS:

- A. Sheet piling shall be left in place unless otherwise indicated.

- B. When indicated, remove the excavation support system without endangering the constructed or adjacent structures, utilities, or property. Immediately backfill all voids left or caused by withdrawal of excavation support systems with bank-run gravel, screened gravel or select borrow by tamping with tools specifically adapted for that purpose.
 - C. When tiebacks are used, release tension in tiebacks as the excavation is backfilled. Do not leave tensioned tieback in place at the completion of the Work.
 - D. The excavation support system left-in-place shall be cut-off a minimum of two feet below the bottom of the next higher foundation level or a minimum of five feet below finished grade.
 - E. Conduct survey of the locations and final cut-off elevations of the excavation support systems left in place.
- 3.04 CONTRACT CLOSEOUT:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 32 12 05M

BITUMINOUS CONCRETE

This Section modifies portions of Section 32 12 05 entitled “Bituminous Concrete” (APWA 2017 as outlined below).

Add Article 1.1, paragraph B as follows:

- B. Restoration Work within University Avenue shall be according to UDOT 2022 Standard Specification Sections 02735 Micro-Surfacing, 02741 Hot Mix Asphalt (HMA), and/or 02744 Stone Matrix Asphalt.

Delete Article 1.4, paragraph D.7 and replace with the following:

- 7. Binder target percentage, dust to binder ratio, and the following as applicable.
 - a. For Marshall mix design provide (1) tensile strength ratio (moisture sensitivity), (2) voids in the mineral aggregate (VMA), (3) stability, (4) flow, (5) voids in the bituminous mix, (6) voids filled with bituminous binder (VFA), (7) virgin binder replacement, (8) RAP asphalt content, and (9) effective asphalt content.
 - b. For Superpave mix design provide (1) voids in the mineral aggregate (VMA), (2) voids filled with bituminous binder (VFA), and (3) Hamburg Wheel Tracker results.

Delete Article 2.3, paragraph D and replace with the following:

- D. RAP or ROSP: Free of detrimental quantities of deleterious materials.
 - 1. Allowed up to 15 percent by weight of RAP or binder, whichever is lesser, with no change in specified binder grade.
 - 2. Allowed from 15 to 25 percent by weight of RAP or binder, whichever is lesser, if the binder grade is adjusted according to AASHTO M323 to meet the specified binder grade.
 - 3. Determine RAP binder content by chemical extraction.

Delete Table 4 from Article 2.4, paragraph B and replace with the following:

Table 4 - Master Grading Band limits - Marshall Mix Design							
Sieve	Aggregate Grade						
	DM-1	DM-3/4	DM-1/2	DM-3/8	OM-1/2	FM-1	FM-1/2
1 inch	100						
3/4 inch		100				100	
1/2 inch	75 - 91		100		100	90 - 100	100
3/8 inch		75-91		100	93 - 100	60 - 100	90 - 100
No. 4	47 - 61	46-62	60 - 80	60 - 80	36 - 44	15 - 40	30 - 50
No. 8					14 - 21	4 - 12	5 - 15
No. 16	23 - 33	22-34	28 - 42	28 - 42			
No. 50	12 - 22	11-23	11 - 23	11 - 23			2 - 5
No. 200	3 - 7	3-7	3 - 7	3 - 7	2 - 4	2 - 5	
NOTES <ul style="list-style-type: none"> (a) Gradation is expressed in percent passing by weight. ASTM C136. Percentage of fines passing No. 200 sieve determined by washing, ASTM C117. (b) Friction Mixture, ASTM D 3515. (c) The alpha portion of the grade designator (DM, OM, FM) represents dense mix, open mix, and friction mix. The numerical portion (1, 3/4, 1/2) represents the <i>maximum</i> sieve size. 							

Delete Table 6 from Article 2.4, paragraph D and replace with the following:

D. Design Parameters: Table 6, determined by AI MS2.

Table 6 - Mix Design Parameters						
Criteria		SuperPave			Marshall	
Mix Designator	(a)	50Nd	75Nd	100Nd	50 blow	75 blow
Compaction (blows)	(b)	-			50	75
Compaction (gyrations)		50	75	100	-	
Design Air Void Target, percent		3.5			3.5	
Stability, lbs., minimum	(d)	-			1200	1800
Flow, in 0.01 inch units	(d)	-			10-18	
Voids in Mineral Aggregate (VMA), percent, minimum, relative to maximum or nominal sieve size grading and calculated using Gsb (dry) for virgin aggregate and RAP aggregate		ASTM D 3203			ASTM D 6927	
		Maximum Grading			Nominal Grading	
		1		12.0	1	13.0
		3/4		13.0	3/4	14.0
		1/2		14.0	1/2	15.0
		3/8		15.0	3/8	16.5
RAP or ROSP specific gravity for calculations		Gsb (dry) by chemical extraction				
Dust to Binder Ratio, maximum		1.4			1.6	
Tensile Strength Ratio (moisture sensitivity), minimum	(e)	-			0.80	
Rutting (Hamburg rut test)	(f)	AASHTO T324				
Road Class I		-			-	-
Road Class II		15 mm/10,000 passes			-	-
Road Class III		10 mm/20,000 passes			-	-
NOTES						
(a) Road Class is defined in Section 32 01 31						
(b) 100Nd mix is for very high traffic applications only as defined by ENGINEER. 100Nd mix is intended for lower lift applications or surface applications with proactive seal coat program.						
(c) Number of compaction blows each end of specimen.						
(d) Design Density Target: ASTM D 2041. Percent of maximum theoretical specific gravity						
(e) Stability, Flow, Voids: ASTM D 6927.						
(f) Tensile Strength Ratio (moisture sensitivity): ASTM D 4867. Use freeze thaw conditioning. Compact test specimen to seven (7) percent plus or minus one (1) percent air voids.						
(g) With testing performed at temperatures representing the <u>specified</u> binder grade in the Hamburg rut test, the average rut depth of two (2) mix design test samples is less than amount shown for the respective Road Classes.						

END OF SECTION

SECTION 32 17 23
PAVEMENT MARKING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide pavement marking as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. Military and Government Specs & Standards (Naval Publications and Form Center (NPFC):

- 1. TT-P-1952F: Paint, Traffic and Airfield Marking, Waterborne
- 2. FS 595B: Colors Used in Government Procurement

- B. American Standards for Testing of Materials (ASTM):

- 1. D562: Standard Test Method for Consistency of Paints
- 2. D1644: Standard Test Methods for Nonvolatile Content of Varnishes
- 3. D2805: Standard Test Method for Hiding Power of Paints by Reflectometry
- 4. D3723: Standard Test Method for Measuring Neutron Fluence and Average Energy from $^3\text{H(d,n)}$ ^4He Neutron Generators by Radioactivation Techniques
- 5. D3960: Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
- 6. D5381: Standard Guide for X-Ray Fluorescence (XRF) Spectroscopy of Pigments and Extenders
- 7. E1347: Standard Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Test Results:
 - 1. Provide test reports of material supplied.

1.04 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.05 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Furnish paint in sealed containers that legibly indicate at time of use designated name, formula or specification number, batch number, color, date of manufacturer, manufacturer's name, formulation number, and directions.

PART 2 - PRODUCTS

2.01 PAINT:

- A. FS TT-P-1952F, Type II.
- B. Paint shall be homogeneous, easily stirred to smooth consistency, and show no hard settlement or other objectionable characteristics during storage period of 6 months.
- C. Paint shall meet the requirements for Acrylic Water Based Paint as specified in Table 32 17 23-1 below.

Table 32 17 23-1					
Property	White	Yellow	Blue	Red	Test
Pigment – Percent by weight, minimum	60 - 62	60 - 62	60 - 62	60 - 62	ASTM D3723
Total Solids – Percent by weight, minimum	77 +/-2	77 +/-2	77 +/-2	77 +/-2	ASTM D1644
Nonvolatile Vehicle – Percent by weight vehicle, minimum	42 +/-2	42 +/-2	42 +/-2	42 +/-2	ASTM D3723 ASTM D1644
Viscosity, KU at 77 degrees F	80-110	80-110	80-100	80-110	ASTM D562
Volatile Organic Content (VOC) – g/L, maximum	<100	<100	<100	<100	ASTM D3960
Color Definition	#37925	#33538	#35180	#31136	FS 595B
Directional Reflectance, minimum	85 percent	NA	NA	NA	ASTM E1347
Dry Opacity – minimum (5 mils wet)	0.92	0.92	0.92	0.92	ASTM D2805

- D. Traffic Pickup Time: Paint may not smear or track 10 minutes after application using standard application equipment, at the mil thickness required, and with an ambient shaded temperature of at least 50 degrees F.
- E. Additional Requirements
1. Free of lead, chromium, and other related heavy metals. Refer to ASTM D5381.

2. Refer to ASTM D5381 for tests used to verify paint samples meet ASTM requirements.
- F. Manufacturers:
1. Allstates Coatings Co.
 2. Swarco Colorado Paint Company II, LLC
 3. SealMaster

PART 3 - EXECUTION

3.01 APPLICATION EQUIPMENT:

- A. Machines, tools, and equipment used in performance of work shall be capable of applying stripe widths indicated, at paint coverage rate specified, and of even uniform thickness with clear-cut edges.
- B. Paint Applicator:
1. Traffic Line Paint Applicator:
 - a. Self-propelled or mobile-drawn pneumatic spraying machine with suitable arrangements of atomizing nozzles and controls to obtain specified results.
 - b. Speed during application of not less than 5 mph.
 - c. Spray mechanism tanks with air-driven mechanical agitators.
 - d. Equip with quick-action valves conveniently located, and include necessary pressure regulator and gauges in full view and reach of operator.
 - e. Provide paint strainers in supply lines to ensure freedom from residue and foreign matter that may cause malfunction of spray guns.
 2. Provide pneumatic spray guns for application of paint for letters, handicapped symbols, and hand application of paint in areas where mobile paint applicator cannot be used.
- C. Provide stencils for handicapped symbols and letters.
- D. Sandblasting Equipment:
1. Includes air compressor, hoses, and nozzles of size and capacity as required for cleaning surfaces to be painted.

2. Compressor shall be capable of furnishing not less than 150 cfm of air at pressure of not less than 90 psi at nozzle for each nozzle used.

3.02 PREPARATION:

- A. Cure pavement surfaces for period of not less than 30 days before application of marking materials.
- B. Clean surfaces to be marked before application of paint.
- C. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water or combination of these methods as required.
- D. Remove rubber deposits and other coatings adhering to pavement with scrapers, wire brushed, sandblasting, approved chemicals or mechanical abrasion.

3.03 APPLICATION:

- A. Apply paint pneumatically.
- B. Apply evenly to clean, dry surfaces of pavement at rate producing initial (wet) thickness of 15 mils, and only when air and pavement temperatures are above 50 degrees F and less than 90 degrees F. Do not apply when the relative humidity exceeds 85 percent or when the temperature falls below the dew point. Maintain paint temperature within these same limits.
- C. Provide guidelines and templates as necessary to control paint application. Special precautions shall be taken in marking letters and handicapped symbols. Edges of markings shall be sharply outlined.
- D. Maximum drying time requirements of paint will be enforced to prevent undue softening of bitumen and pickup, displacement or discoloration by tires of traffic. If there is deficiency in drying of markings, discontinue painting operations until cause of slow drying is determined and corrected.
- E. Protect markings from traffic until dry to prevent tracking.

3.04 CLEANING:

- A. At completion of work, remove rubbish, debris, equipment, and excess material from site. Clean adjoining surfaces soiled by and during this work.

3.05 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Section includes:

1. PVC coated chain link fence framework, fabric, and accessories.
2. Excavation for post bases.
3. Manual gates and related hardware.

1.02 REFERENCES:

A. American Association of State Highway and Transportation Officials (AASHTO):

1. M181: Standard Specification for Chain-Link Fence.

B. ASTM International (ASTM):

1. A53/A53M: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. A121: Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
3. A392: Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
4. F567: Standard Practice for Installation of Chain-Link Fence.
5. F626: Standard Specification for Fence Fittings
6. F654: Standard Specification for Residential Chain Link Fence Gates.
7. F668: Standard Specification for Polyvinyl (PVC), Polyolefin and Other Polymer-Coated Steel Chain Link Fence Fabric
8. F900: Standard Specification for Industrial and Commercial Swing Gates.
9. F934: Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials
10. F1184: Standard Specification for Industrial and Commercial Horizontal Slide Gates.

11. F1665: Standard Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Barbed Wire Used with Chain-Link Fence

C. Chain Link Fence Manufacturers Institute (CLFMI):

1. PM 2445: Chain Link Fence Manufacturers Institute Product Manual.

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00.

1. Sustainable Design Submittals.
2. Submit Manufacturer's specifications, drawings, details, and fence layout with appurtenances.
3. Submit two samples of fencing materials. Mark or tag each sample and submit 30 days prior to erection of fence.
4. Submit certified test reports with results of tests for fence finish.
5. Submit shop drawings, samples, and certificates simultaneously as one complete package.

1.04 SPARE PARTS:

A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sustainability Standards Certifications.

1.06 DELIVERY STORAGE AND HANDLING:

A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 MANUFACTURERS OR APPROVED EQUAL:

- A. Wheatland Tube Co.,
- B. Master Halco, Inc.,
- C. Southwestern Wire, Inc.,

2.02 GENERAL:

- A. Dimensions indicated herein for roll-formed pipe and H-sections are outside dimensions, excluding coatings.
- B. Fence fabric height shall be 4 feet on top of the retaining wall and Diversion Box Structure and 6 feet for swing gates and adjacent connecting fences unless otherwise indicated.
- C. Fencing materials shall be galvanized and PVC coated after fabrication.
- D. The color of the fencing fabric, poles, and fittings shall be black.
- E. Provide framework, fabric, accessories, and gates in accordance with ASTM F567.
- F. Fence heights as indicated with top rail and bottom tension wire.
- G. Gates:
 - 1. Industrial and Commercial:
 - a. Provide swing gates in accordance with ASTM F900.

2.03 FENCE FABRIC:

- A. Colored PVC-coated steel fabric with galvanized and factory-painted steel posts, hardware, and fittings.
- B. Fence fabric shall be 9-gauge steel wire, 2-inch mesh, with top selvages knuckled and bottom selvages twisted and barbed.
- C. Fabric shall be hot-dip galvanized and PVC coated according to ASTM F668, Class 2a or Class 2b. The weight of the zinc shall meet the requirements of STM F 668, Table 4.

2.04 TENSION WIRE:

- A. Tension wire shall be located at the bottom of the fabric and shall consist of 7-gauge wire complying with ASTM F 1664. Wire gauge specified is the core wire gauge. The color shall match the coating of the chain link fabric and shall be Class 2a or Class 2b. Tension wire shall be interlaced with the fabric or attached to the fabric with wire ties at a spacing of no more than 18 inches apart.

2.05 TIE WIRES AND HOG RINGS:

- A. Galvanized minimum zinc coating 1.20 oz/ft², 9-gauge (0.148-inch) steel wire in compliance with ASTM F626. Tie wire and hog rings shall be polymer coated and match the color of the fence system.

2.06 FRAMING AND ACCESSORIES:

- A. Round steel pipe and rail: Schedule 40 standard weight pipe, in accordance with ASTM F1083, 1.8 oz/ ft² hot dip galvanized zinc exterior and 1.8 oz/ft² hot dip galvanized zinc interior coating. Intermediate Strength Grade: Minimum yield strength 50,000 psi.
 - 1. Line post shall be 2-3/8" outside diameter, 1.8 oz/ft² zinc coating.
 - 2. End, Corner, Pull post 2-7/8" outside diameter, 1.8 oz/ft² zinc coating.
 - 3. Top, brace, bottom, and intermediate rails, 1.660" outside diameter, 1.8 oz/ft² zinc coating.
- B. Polymer Coated Pipe: Polymer coated pipe shall have a PVC coating fused and adhered to the exterior zinc coating of the galvanized pipe in accordance with ASTM F1043. The minimum thickness of the PVC coating shall be 10-mils (0.254 mm). The color shall match fabric black per ASTM F934.
- C. Gate Posts:
 - 1. 2-7/8 inches outside diameter steel pipe and gate posts, for gate leaves up to and including 6 feet wide, weighing not less than 5.79 lb. per ft., or 2-1/2 inch square steel tube weighing not less than 5.14 lb. per ft., or 3-1/2 inch roll-formed, steel corner section weighing not less than 5.14 lb/ft.
 - 2. 4 inch outside diameter steel pipe, gate posts for gate leaves over 6 feet wide and up to and including 13 feet wide and weighing not less than 9.10 lb/ft .
 - 3. 6-5/8 inch outside diameter steel pipe, gate posts for gate leaves over 13 feet wide and up to and including 18 feet weighing not less than 18.97 lb/ft.
- D. Tension and Brace Bands: Galvanized pressed steel complying with ASTM F626, minimum steel thickness of 12 gauge (0.105 inch), minimum width of 3/4 inch and minimum zinc coating of 1.20 oz/ft². Secure bands with 5/16-inch galvanized steel carriage bolts.
- E. Terminal Post Caps, Line Post Loop Tops, Rail and Brace Ends, Boulevard Clamps, Rail Sleeves: In compliance to ASTM F626, pressed steel galvanized after fabrication having a minimum zinc coating of 1.20 oz/ft² and PVC coated.
- F. Truss Rod Assembly: In compliance with ASTM F626, 3/8-inch diameter steel truss rod with a pressed steel tightener, minimum zinc coating of 1.2 oz/ft² and PVC coated, assembly capable of withstanding a tension of 2,000 lbs.
- G. Tension Bars: Tension bars shall be in accordance with ASTM F626 and shall be galvanized steel one-piece length 2-inch less than the fabric height. Minimum zinc coating 1.2 oz. /ft². Bars for 2-inch mesh shall have a minimum cross section of 3/16 inch by 3/4-inch.

- H. Polymer Coated Color Fittings: In compliance with ASTM F626, PVC coating minimum thickness 0.006-inch fused and adhered to the zinc coated fittings. Match color to fence system.

2.07 STRETCHER BARS:

- A. Flat bars with minimum cross section dimensions of 1/4-inch by 3/4 inch, full height of fabric, secured with bar bands of minimum 11-gage sheet steel, spaced approximately 15 inches on centers and bolted with 3/8-inch diameter bolts, for attaching fabric to terminal posts.

2.08 SWING GATES:

- A. **Swing Gates:** Galvanized steel pipe welded fabrication in compliance with ASTM F900. Gate frame members 1.900-inch outside diameter, ASTM F 1083 schedule 40 galvanized steel pipe. Frame members spaced no greater than 8 ft. apart vertically and horizontally. Welded joints protected by applying zinc-rich paint in accordance with ASTM Practice A 780. Positive locking gate latch, pressed steel galvanized after fabrication. Galvanized malleable iron or heavy gauge pressed steel post and frame hinges. Provide lockable drop bar and gate holdbacks with double gates. Match gate fabric to that of the fence system. Gateposts per ASTM F1083 schedule 40 galvanized steel pipe. The gatepost diameter from table 2.5.B. Gate frames and gate posts shall be PVC coated and match the color of the fence system.
- B. Gateposts: Schedule 40 pipe in compliance with ASTM F1083.

Gate fabric height up to and including 6 ft.		
Gate leaf width	Post Outside Diameter	Weight
up to 4 ft.	2.375 in.	3.65 lb/ft
over 4 ft. to 10 ft.	2.875 in.	5.79 lb/ft
over 10 ft. to 18 ft.	4.000 in.	9.11 lb/ft
Gate fabric height over 6 ft. to 12 ft.		
Gate leaf width		
up to 6 ft.	2.875 in.	5.79 lb/ft
over 6 ft. to 12 ft.	4.000 in.	9.11 lb/ft
over 12 ft. to 18 ft.	6.625 in.	18.97 lb/ft
over 18 ft. to 24 ft.	8.625 in.	28.58 lb/ft

2.09 GATE HINGES:

- A. Heavy pattern of adequate strength for gate size, with large bearing surfaces for clamping or bolting in position.

2.10 LATCH:

- A. Gates with suitable latch, accessible from both sides and with provision for padlocking.

2.11 CONCRETE FOOTINGS:

- A. Section 03 30 00 Cast-In-Place Concrete, Class A concrete.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Examine conditions under which fence and gates are to be installed. Notify Engineer, in writing, of improper conditions of work.
- B. Do not proceed with work until unsatisfactory conditions have been corrected.
- C. Verify measurements at site.
- D. Check location of underground work to make sure fence footings clear utilities and drainage work.
- E. Do not install fence until final grading is complete and finish elevations are established.
- F. Do not drive equipment on areas to be landscaped, except as accepted by Engineer. Areas not accessible from roads shall be protected with heavy wood planking. Remove barricades and protection at completion of project. Repair damaged landscape surfaces.

3.02 INSTALLATION:

- A. Footings:
 - 1. Vertical sides to minimize up-lift. Dispose of excavated material in accordance with Section 01 74 23.
 - 2. Rod and compact concrete around posts. Slope top of footings above level of adjacent grade, and trowel finish.
 - 3. Time of Set: 48 hours before rails are erected or before fabric is applied or stretched.
- B. Framing:
 - 1. Install corner posts where the fence line changes direction by more than 30 degrees.
 - 2. Set posts in concrete footings, plumb and true to line.
 - 3. Brace and truss end, pull, corner, and gate posts to adjacent line posts. Provide brace to match top rail spaced midway between top rail and tension wire and extending to adjacent line posts. Provide brace to match top rail spaced midway between top rail and tension wire and extending to adjacent line post. Truss diagonally with 5/16-inch diameter tension rod with turnbuckle.

4. Fasten top rail to end, pull, gate and corner posts. Pass top rail through fittings of line posts.
5. Provide expansion and contraction joints in top rail for each 100 linear feet of fence.
6. Fasten bottom tension wire to end, pull, gate, corner, and line posts.
7. Maximum area of unbraced fence shall not exceed 1,500 square feet.
8. Use galvanized sleeve and grout posts or install with suitable galvanized flange casings and galvanized anchor bolts as accepted by Engineer.
9. When rock is encountered, set posts into rock a minimum depth of 12 inches for line posts and 18 inches for terminal posts. If solid ledge is encountered without overburden of soil. Provide post holes at least 1 inch greater in diameter than post, fill post holes with concrete work post into hole taking care not to cause voids, remove excess concrete and crown remainder at top to shed water. Where solid rock is covered by overburden, do not exceed total setting depth required for setting in earth, grout posts into rock as described.

C. Fabric:

1. Place fabric on outside of posts and stretch to avoid bulging or buckling.
2. Fasten at line posts, top rail, and bottom tension wire with zinc PVC coated ties. Space ties not more than 15 inches apart on line posts and not more than 24 inches apart on rail and tension wire.
3. Fasten at terminal posts at intervals not exceeding 15 inches using flat or beveled galvanized steel bands with 5/16-inch x 1-1/4 inch galvanized carriage bolts and nuts.
4. Make tie connections on interior side of fence.
5. Provide steel angle metal closures where finished ground surface is more than two inches below bottom tension wire. Bolt steel angle to fence posts, and install reinforcing rods and bracing members as accepted. Install rods of accepted length vertically. Where drainage ditches cross fence line, provide concrete ditch lining and steel reinforcing bar grill.
6. Install gates plumb, level, and secure for full width of opening and hardware adjusted for smooth operation.
7. Electrical Ground where a power line carrying more than 600 volts passes over fence, install ground rod at nearest point directly below each point of crossing.
 - a. Provide at least one electrical ground for each 1,000 feet of fence, located near the center of the run.

- b. Ground at or near point of overhead line crossing and at distances not exceeding 150 feet each side of line crossing.
- c. Make connection to ground from metal posts electrically continuous with the fencing.
- d. Vertically drive or drill in the grounding rod until the top of the rod is approximately six (6) inches below the top of the ground. Connect a No. 6 solid copper conductor to the rod and to the fence by a UL-listed method so that each element of the fence is grounded.
- e. Set ground rods eight (8) feet from fence.

3.03 REPAIR:

- A. Remove and replace fencing which is improperly located or is not true to line, grade and plumb within tolerances as indicated.
- B. Repair damaged vinyl-coated components as recommended by manufacturer.

3.04 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 32 32 16

PRECAST MODULAR BLOCK RETAINING WALLS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This Section includes furnishing all materials and labor required for the design and construction of a precast concrete modular block (PMB) retaining wall with or without geosynthetic reinforcement. Precast modular block retaining wall blocks under this section shall be cast utilizing a wet-cast concrete mix and exhibit a final handling weight in excess of 1,000 pounds per unit.
- B. Scope of Work: The work shall consist of furnishing materials, labor, equipment, and supervision for the construction of a precast modular block (PMB) retaining wall structure in accordance with the requirements of this section and in acceptable conformity with the lines, grades, design, and dimensions shown in the project site plans.

1.02 REFERENCES:

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. M 145: Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
 - 2. M 288: Geotextile Specification for Highway Applications
 - 3. T104: Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
 - 4. T267: Standard Method of Test for Determination of Organic Content in Soils by Loss of Ignition
 - 5. LRFD Bridge Design Specifications
- B. American Concrete Institute (ACI)
 - 1. 201.2: Guide to Durable Concrete
 - 2. 318: Building Code Requirements for Structural Concrete and Commentary.
- C. American Society of Civil Engineers (ASCE)
 - 1. 7: Minimum Design Loads for Buildings and Structures

D. ASTM International (ASTM):

1. C33: Standard Specification for Concrete Aggregates
2. C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
3. C94: Standard Specification for Ready-Mixed Concrete
4. C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
5. C138: Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
6. C143: Standard Test Method for Slump of Hydraulic-Cement Concrete
7. C150: Standard Specification for Portland Cement
8. C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
9. C260: Standard Specification for Air-Entraining Admixtures for Concrete
10. C494: Standard Specification for Chemical Admixtures for Concrete
11. C595: Standard Specification for Blended Hydraulic Cements
12. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
13. C666: Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
14. C845: Standard Specification for Expansive Hydraulic Cement
15. C920: Standard Specification for Elastomeric Joint Sealants
16. C989: Standard Specification for Slag Cement for Use in Concrete and Mortars
17. C1116: Standard Specification for Fiber-Reinforced Concrete
18. C1157: Standard Performance Specification for Hydraulic Cement
19. C1218: Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
20. C1240: Standard Specification for Silica Fume Used in Cementitious Mixtures
21. C1611: Standard Test Method for Slump Flow of Self-Consolidating Concrete

22. C1776: Standard Specification for Wet-Cast Precast Modular Retaining Wall Units
23. D448: Standard Classification for Sizes of Aggregate for Road and Bridge Construction
24. D698: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ [600 kN-m/m³])
25. D1241: Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
26. D1556: Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
27. D1557: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ [2,700 kN-m/m³])
28. D2487: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
29. D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)
30. D4254: Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
31. D3786: Standard Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method
32. D4318: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
33. D4354: Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
34. D4355: Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc-Type Apparatus
35. D4491: Standard Test Methods for Water Permeability of Geotextiles by Permittivity
36. D4533: Standard Test Method for Trapezoid Tearing Strength of Geotextiles
37. D4595: Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
38. D4767: Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

39. D4972: Standard Test Methods for pH of Soils
40. D4632: Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
41. D4751: Standard Test Method for Determining Apparent Opening Size of a Geotextile
42. D4759: Standard Practice for Determining the Specification Conformance of Geosynthetics
43. D4833: Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
44. D4873: Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
45. D5262: Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
46. D5321: Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
47. D5818: Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics
48. D5970: Standard Test Method for Deterioration of Geotextiles from Outdoor Exposure
49. D6241: Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe
50. D6637: Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
51. D6638: Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
52. D6706: Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
53. D6916: Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)
54. D6938: Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

- 55. D6992: Standard Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method
- 56. G51: Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
- 57. G57: Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method
- E. International Building Code (IBC)
- F. Federal Highway Administration (FHWA)
 - 1. FHWA-NHI-10-024: GEC-11 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Vol. I
 - 2. FHWA-NHI-10-025: GEC-11 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Vol II
- G. National Concrete Masonry Association (NCMA):
 - 1. TR127B: Design Manual for Segmental Retaining Walls
 - 2. TR146: Segmental Retaining Wall Installation Guide
 - 3. TR146: Segmental Retaining Walls – Seismic Design Manual
- 1.03 DEFINITIONS:
 - A. Precast Modular Block (PMB) Unit: Concrete, modular facing block provided by an authorized manufacturer.
 - B. Geogrid: A geosynthetic material manufactured of high tensile materials specifically for the purpose of reinforcing and creating a structural soil mass.
 - C. Drainage Aggregate: Clean, crushed rock located within and immediately behind PMB units to facilitate drainage and avoid compaction in close proximity to PMB wall units.
 - D. Reinforced Soil: Soil zone extending from the Drainage aggregate zone to the back of the embedded geogrid.
 - E. Foundation Soil: Soil zone immediately beneath the retaining wall facing units, the wall leveling pad and the reinforced soil zone.
 - F. Retained Soil: Soil immediately behind retaining wall facing and drainage aggregate for modular gravity structures or behind the reinforced soil for wall that utilize geogrid.
 - G. Construction Drawings: Approved final plan for construction prepared and stamped by the wall design engineer licensed to practice in the State of Utah.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Product Data. The Contractor shall submit the retaining wall product submittal package to the Engineer for review and approval. The submittal package shall include technical specifications and product data from the manufacturer for the following:
 - 1. Precast Modular Block System brochure, product data, and installation instructions.
 - 2. Manufacturer's test reports certifying that the PMB units manufactured at their production facility meet the requirements of this Specification and the requirements of the Construction Drawings.
- C. Contractor shall submit one electronic PDF file of the Construction Drawings for all retaining walls on the project.
 - 1. The design shall be prepared by a Professional Engineer licensed to practice in the State of Utah.
 - 2. The design shall be per NCMA Design Guidelines for Segmental Retaining Walls, or the AASHTO Standard Specifications for Highway Bridges, whichever is applicable as determined by the retaining wall design engineer.
 - 3. Construction Drawings shall include:
 - a. The retaining wall layout and retaining wall heights.
 - b. Proper placement, lengths, and types of geogrid reinforcement where necessary.
 - c. Typical wall sections.
 - d. Types, locations and properties of all drainage materials, appurtenances and special installation requirements not covered in this specification.
 - e. Retaining wall elevation views.
 - f. Any soils information or testing conducted in addition to that included within the project drawings and specifications.
 - g. Design assumptions.
 - 4. If geogrid reinforcement is required in the final engineered construction drawings, submit manufacturer's product literature, product testing reports and a twelve inch or larger sample of each type to be used in wall construction.

5. Submit gradation reports for aggregates used for the wall leveling pad, unit / drainage fill and for select reinforced fill if required in the final engineered wall design.
 6. All submittals must be provided and reviewed prior to the start of retaining wall construction.
 7. Drainage Pipe, if required.
 8. Geotextile
- D. Installer Qualification Data. The Contractor shall submit the qualifications of the business entity responsible for installation of the retaining wall, the Retaining Wall Installation Contractor, per the requirements of this section.

1.05 ADMINISTRATIVE REQUIREMENTS:

- A. Preconstruction Meeting. The General Contractor shall schedule a preconstruction meeting at the project site prior to commencement of retaining wall construction. Participation in the preconstruction meeting shall be required of the General Contractor, Retaining Wall Design Engineer, Retaining Wall Installation Contractor, Grading Contractor, and Engineer. The General Contractor shall provide notification to all parties at least 10 calendar days prior to the meeting.

1. Preconstruction Meeting Agenda:

- a. The Retaining Wall Design Engineer shall explain all aspects of the retaining wall construction drawings.
- b. The Retaining Wall Design Engineer shall explain the required bearing capacity of soil below the retaining wall structure and the shear strength of in-situ soils assumed in the retaining wall design to the Engineer.
- c. The Retaining Wall Design Engineer shall explain the required shear strength of fill soil in the reinforced, retained and foundation zones of the retaining wall to the Engineer.
- d. The Retaining Wall Design Engineer shall explain any measures required for coordination of the installation of utilities or other obstructions in the reinforced or retained fill zones of the retaining wall.
- e. The Retaining Wall Installation Contractor shall explain all excavation needs, site access and material staging area requirements to the General Contractor and Grading Contractor.

1.06 CONSTRUCTION SHOP DRAWINGS PREPARATION

- A. The Retaining Wall Design Engineer shall coordinate the retaining wall construction shop drawing preparation with the project Civil Engineer and project Geotechnical Engineer. The General Contractor shall furnish the Retaining Wall Design Engineer the following project information required to prepare the construction shop drawings. This information shall include, but is not limited to, the following:
 - 1. Current versions of the site, grading, drainage, utility, erosion control, landscape, and irrigation plans;
 - 2. electronic CAD file of the civil site plans listed in (1);
 - 3. report of geotechnical investigation and all addenda and supplemental reports;
 - 4. recommendations of the project Geotechnical Engineer regarding effective stress shear strength and total stress shear strength (when applicable) parameters for in-situ soils in the vicinity of the proposed retaining wall(s) and for any fill soil that may potentially be used as backfill in retained and/or foundation zones of the retaining wall.
- B. The Retaining Wall Design Engineer shall provide the Engineer with a certificate of professional liability insurance verifying the minimum coverage limits of \$1 million per claim and \$1 million aggregate.
- C. Design of the precast modular block retaining wall shall satisfy the requirements of this section. Where local design or building code requirements exceed these specifications, the local requirements shall also be satisfied.
- D. The Retaining Wall Design Engineer shall note any exceptions to the requirements of this section by listing them at the bottom right corner of the first page of the construction shop drawings.
- E. Approval or rejection of the exceptions taken by the Retaining Wall Engineer will be made in writing as directed by the Engineer.
- F. The precast modular block design, except as noted herein, shall be based upon AASHTO Load and Resistance Factor Design (LRFD) methodology.
- G. In the event that a conflict is discovered between these specifications and a reasonable interpretation of the design specifications and methods referenced in paragraph F above, these specifications shall prevail.
- H. Soil Shear Parameters. The Retaining Wall Design Engineer shall prepare the construction shop drawings based upon soil shear strength parameters from the available project data and the recommendations of the project Geotechnical Engineer. If insufficient data exists to develop the retaining wall design, the Retaining Wall Design

Engineer shall communicate the specific deficiency of the project information or data to the Owner in writing.

- I. Allowable bearing pressure requirements for each retaining wall shall be clearly shown on the construction drawings.
- J. Global Stability. Overall (global) stability shall be evaluated in accordance with the principals of limit equilibrium analysis as set forth in FHWA-NHI-10-024 Volume I and FHWA-NHI-10-025 Volume II GEC 11 Design of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes. The minimum factors of safety shall be as follows:
 - 1. Normal Service (Static): 1.4
 - 2. Seismic: 1.1
 - 3. Rapid Drawdown (if applicable): 1.2
- K. Seismic Stability. Seismic loading shall be evaluated in accordance with AASHTO Load and Resistance Factor Design (LRFD).

1.07 PERFORMANCE REQUIREMENTS:

- A. Basis of Design: Design of segmental retaining walls is based on products indicated. If comparable products of other manufacturers are proposed, provide engineering design for proposed products, including comprehensive engineering analysis by a qualified and registered professional engineer in State of Utah, using performance requirements and design criteria indicated.
- B. Delegated Design: Design segmental retaining walls, including comprehensive engineering analysis by a qualified and registered professional engineer in State of Utah, using performance requirements and design criteria indicated.
- C. Structural Performance: Engineering design shall be based on the following loads and be according to the current version of AASHTO LRFD Standard Specification for Highway Bridges.
 - 1. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
 - 2. Superimposed loads (surcharge) indicated on Drawings.
- D. Seismic Performance: Engineering design shall be based on the following loads and factors and be according to the current version of AASHTO LRFD Standard Specification for Highway Bridges.
 - 1. Gravity loads due to soil pressures resulting from grades indicated.
 - 2. Superimposed loads (surcharge) indicated on Drawings.

3. Horizontal Peak Ground Acceleration (A) for Project: 0.62g.

1.08 PRECONSTRUCTION TESTING:

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
1. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D6706.
 2. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D5321.

1.09 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Prepare design, including calculations and drawings, under the direction of a Professional Engineer registered in State of Utah and having the following qualifications:
1. Not less than ten (10) years' experience in the design of precast modular block retaining wall systems.
 2. Completed not less than five (5) successful segmental retaining wall systems for projects of equal type.
- C. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.
- D. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects.
1. Build mockup of segmental retaining wall approximately 72 inches long by not less than 36 inches high above finished grade at front of wall.
 - a. Include typical soil reinforcement.
 - b. Include typical base and cap or finished top construction.
 - c. Include backfill to typical finished grades at both sides of wall.
 - d. Include typical end construction at one end of mockup.
 - e. Include 36-inch return at 1 end of mockup, with typical corner construction.
 2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

- E. Preinstallation Conference: Conduct conference at Project site.
1. Review methods and procedures related to segmental retaining walls including, but not limited to, the following:
 - a. Structural load limitations.
 - b. Construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
- F. Retaining Wall Installation Contractor Qualifications. In order to demonstrate basic competence in the construction of precast modular block walls, the Retaining Wall Installation Contractor shall document compliance with the following:
1. Experience.
 - a. Construction experience with a minimum of 30,000 square feet of the proposed precast modular block retaining wall system.
 - b. Construction of at least ten (10) precast modular block (large block) retaining wall structures within the past three (3) years.
 - c. Construction of at least 50,000 square feet of precast modular block (large block) retaining walls within the past three (3) years.
 2. Retaining Wall Installation Contractor experience documentation for each qualifying project shall include:
 - a. Name and location
 - b. Date (month and year) of construction completion
 - c. Contact information of Owner or General Contractor
 - d. Type (trade name) of precast modular block system built
 - e. Maximum height of the wall constructed
 - f. Face area of the wall
 3. In lieu of the requirements set forth in items 1 and 2 above, the Retaining Wall Installation Contractor must be a certified Precast Modular Block Retaining Wall Installation Contractor as demonstrated by satisfactory completion of a certified precast modular block retaining wall installation training program administered by the precast modular block manufacturer.
- G. Retaining Wall Design Engineer Qualifications and Statement of Experience. The Retaining Wall Design Engineer shall submit a written statement affirming that he or she has the following minimum qualifications and experience.

1. The Retaining Wall Design Engineer shall be licensed to practice in the State of Utah.
2. The Retaining Wall Design Engineer shall be independently capable of performing all internal and external stability analyses, including those for seismic loading, compound stability, rapid draw-down and deep-seated, global modes of failure.
3. The Retaining Wall Design Engineer shall affirm in writing that he or she has personally supervised the design of the retaining walls for the project, that the design considers all the requirements listed above and that he or she accepts responsibility as the design engineer of record for the retaining walls constructed on the project.
4. The Retaining Wall Design Engineer shall affirm in writing that he or she has personally designed in excess of 100,000 face square feet of modular block earth retaining walls within the previous three (3) years.
5. In lieu of these specific requirements, the engineer may submit alternate documentation demonstrating competency in Precast Modular Block retaining wall design.

H. The Owner reserves the right to reject the design services of any engineer or engineering firm who, in the sole opinion of the Owner, does not possess the requisite experience or qualifications.

1.10 QUALITY CONTROL:

- A. Comply with the requirements specified in Section 01 43 00.
- B. The Engineer shall review all submittals for materials, design, Retaining Wall Design Engineer qualifications and the Retaining Wall Installation Contractor qualifications.
- C. The General Contractor shall retain the services of an Inspection Engineer who is experienced with the construction of precast modular block retaining wall structures to perform inspection and testing. The cost of inspection shall be the responsibility of the General Contractor. Inspection shall be continuous throughout the construction of the retaining walls.
- D. The Inspection Engineer shall perform the following duties:
 1. Inspect the construction of the precast modular block structure for conformance with construction shop drawings and the requirements of this specification.
 2. Verify that soil or aggregate fill placed and compacted in the reinforced, retained and foundation zones of the retaining wall conforms with requirements of this section and exhibits the shear strength parameters specified by the Retaining Wall Design Engineer.

3. Verify that the shear strength of the in-situ soil assumed by the Retaining Wall Design Engineer is appropriate.
4. Inspect and document soil compaction in accordance with these specifications:
 - a. Required dry unit weight
 - b. Actual dry unit weight
 - c. Allowable moisture content
 - d. Actual moisture content
 - e. Pass/fail assessment
 - f. Test location – wall station number
 - g. Test elevation
 - h. Distance of test location behind the wall face
5. Verify that all excavated slopes in the vicinity of the retaining wall are bench-cut as directed by the project Geotechnical Engineer.
6. Notify the Retaining Wall Installation Contractor of any deficiencies in the retaining wall construction and provide the Retaining Wall Installation Contractor a reasonable opportunity to correct the deficiency.
7. Notify the General Contractor, Owner and Retaining Wall Design Engineer of any construction deficiencies that have not been corrected timely.
8. Document all inspection results.
9. Test compacted density and moisture content of the retained backfill with the following frequency:
 - a. At least once every 1,000 square feet (in plan) per 9-inch vertical lift, and
 - b. At least once per every 18 inches of vertical wall construction.
- E. The General Contractor's engagement of the Inspection Engineer does not relieve the Retaining Wall Installation Contractor of responsibility to construct the proposed retaining wall in accordance with the approved construction shop drawings and these specifications.
- F. The Retaining Wall Installation Contractor shall inspect the on-site grades and excavations prior to construction and notify the Retaining Wall Design Engineer and General Contractor if on-site conditions differ from the elevations and grading conditions depicted in the retaining wall construction shop drawings.

1.11 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. The Retaining Wall Installation Contractor shall inspect the materials upon delivery to ensure that the proper type, grade, and color of materials have been delivered.
- C. The Retaining Wall Installation Contractor shall store and handle all materials in accordance with the manufacturer's recommendations as specified herein and in a manner that prevents deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping, UV exposure or other causes. Damaged materials shall not be incorporated into the work.
- D. Retaining wall units shall be stored in a location and manner that protects against excessive weathering and damage.
- E. Contractor shall prevent PMB units from excessive soiling and coming in contact with substances which may stain or adhere to the finished visual surfaces of the unit.
- F. Store geosynthetics in manufacturer's original packaging with labels intact and in accordance with ASTM D4873. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 degrees F or below 32 degrees F, and other conditions that might damage them. Verify identification of geosynthetics before using and examine them for defects as material is placed.
- G. Precast Modular Blocks
 - 1. Precast modular blocks shall be stored in an area with positive drainage away from the blocks. Be careful to protect the block from mud and excessive chipping and breakage. Precast modular blocks shall not be stacked more than three (3) units high in the storage area.
- H. Drainage Aggregate and Backfill Stockpiles
 - 1. Drainage aggregate or backfill material shall not be piled over unstable slopes or areas of the project site with buried utilities.
 - 2. Drainage aggregate and/or reinforced fill material shall not be staged where it may become mixed with or contaminated by poor draining fine-grained soils such as clay or silt.

PART 2 - PRODUCTS

2.01 PRECAST MODULAR BLOCK (PMB) RETAINING WALL UNITS:

- A. Concrete Units: All units shall be wet-cast precast modular retaining wall units conforming to ASTM C1776.

- B. All units for the project shall be obtained from the same manufacturer. The manufacturer shall be licensed and authorized to produce the retaining wall units by the precast modular block system patent holder/licensor and shall document compliance with the published quality control standards of the proprietary precast modular block system licensor for the previous three (3) years or the total time the manufacturer has been licensed, whichever is less.

Table 32 32 16-1 Concrete Mix Properties					
Freeze Thaw Exposure Class ⁽¹⁾	Minimum 28-Day Compressive Strength ⁽²⁾	Maximum Water Cement Ratio	Nominal Maximum Aggregate Size	Aggregate Class Designation ⁽³⁾	Air Content ⁽⁴⁾
Moderate	4,000 psi (27.6 MPa)	0.45	1 inch (25 mm)	3M	4.5% +/- 1.5%
Severe	4,000 psi (27.6 MPa)	0.45	1 inch (25 mm)	3S	6.0% +/- 1.5%
Very Severe	4,500 psi (30.0 MPa)	0.40	1 inch (25 mm)	4S	6.0% +/- 1.5%
Maximum Water-Soluble Chloride Ion (Cl ⁻) Content in Concrete, Percent by Weight of Cement ^(5,6)					0.15
Maximum Chloride as Cl ⁻ Concentration in Mixing Water, Parts Per Million					1000
Maximum Percentage of Total Cementitious Materials By Weight ^(7,9) (Very Severe Exposure Class Only):					
Fly Ash or Other Pozzolans Conforming to ASTM C618					25
Slag Conforming to ASTM C989					50
Silica Fume Conforming to ASTM C1240					10
Total of Fly Ash or Other Pozzolans, Slag, and Silica Fume ⁽⁸⁾					50
Total of Fly Ash or Other Pozzolans and Silica Fume ⁽⁸⁾					35
Alkali-Aggregate Reactivity Mitigation per ACI 201					
Slump (Conventional Concrete) per ASTM C143 ⁽¹⁰⁾			5 inches +/- 1½ inches (125 mm +/- 40 mm)		
Slump Flow (Self-Consolidating Concrete) per ASTM C1611			18 inches – 32 inches (450 mm – 800 mm)		
NOTES:					
(1) Exposure class is as described in ACI 318. “Moderate” describes concrete that is exposed to freezing and thawing cycles and occasional exposure to moisture. “Severe” describes concrete that is exposed to freezing and thawing cycles and in continuous contact with moisture. “Very Severe” describes concrete that is exposed to freezing and thawing cycles and in continuous contact with moisture and exposed to deicing chemicals. Exposure class should be specified by owner/purchaser prior to order placement.					
(2) Test method ASTM C39.					
(3) Defined in ASTM C33 Table 3 <i>Limits for Deleterious Substances and Physical Property Requirements of Coarse Aggregates for Concrete</i> .					
(4) Test method ASTM C231.					
(5) Test method ASTM C1218 at age between 28 and 42 days.					
(6) Where used in high sulfate environments or where alkali-silica reactivity is an issue, water soluble chloride shall be limited to no more than trace amounts (from impurities in concrete-making components, not intended constituents).					
(7) The total cementitious material also includes ASTM C150, C595, C845, C1157 cement. The maximum percentages shall include:					
(a) Fly ash or other pozzolans in type IP, blended cement, ASTM C595, or ASTM C1157.					
(b) Slag used in the manufacture of an IS blended cement, ASTM C595, or ASTM C1157.					
(c) Silica fume, ASTM C1240, present in a blended cement.					
(8) Fly ash or other pozzolans and silica fume shall constitute no more than 25 and 10 percent, respectively, of the total weight of the cementitious materials.					
(9) Prescriptive limits shown may be waived for concrete mixes that demonstrate excellent freeze/thaw durability in a detailed and current testing program.					
(10) Slump may be increased by a high-range water-reducing admixture.					

- C. Concrete used in the production of the precast modular block units shall be first-purpose, fresh concrete. It shall not consist of returned, reconstituted, surplus or waste concrete. It shall be an original production mix meeting the requirements of ASTM C94 and exhibit the properties as shown in Table 32 32 16-1:
- D. Each concrete block shall be cast in a single continuous pour without cold joints.
- E. Depth of units should be as per the Construction Drawings and shall range from 24 inches to 84-inches.
- F. Individual block units shall have a nominal height of between 16 to 18 inches.
- G. Exterior dimensions of the face shall be 46-inch to 48-inch for full units.
- H. Units shall maintain tolerances of +/- 3/16-inch of height and +/- 1/2-inch of width.
- I. Special shape units should be obtained and used where indicated on the final engineered construction drawings.
- J. PMB unit face texture shall be ReCon Limestone, ReCon Granite, RediRock Limestone, or RediRock Kingston.
 - 1. Manufacturers:
 - a. Redi-Rock Retaining Wall Systems
 - b. ReCon Wall Systems, Inc.

2.02 GEOGRID REINFORCEMENT:

- A. Geosynthetic reinforcement shall be high tensile geogrid or geotextile manufactured specifically for soil reinforcement applications.
 - 1. Construction Drawings shall indicate the type, strength, location, and lengths of reinforcement used.
 - 2. The geosynthetic manufacturer shall provide all relevant testing to the wall design engineer for incorporation in the wall design and shall be included in the submittal for the Construction Drawings.
 - 3. No substitutions of geosynthetic shall be allowed that was not evaluated in the Construction Drawings.
- B. Constructability Requirements. Geogrid design embedment length shall be measured from the back of the precast modular block facing unit and shall be consistent for the entire height of a given retaining wall section.

- C. Geogrid shall be positively connected to every precast modular block unit. Design coverage ratio, R_c , as calculated in accordance with AASHTO LRFD Bridge Design Specifications Figure 11.10.6.4.1-2 shall not exceed 0.50.
- D. Preapproved Geogrid Reinforcement Products.
 - 1. Miragrid XT Geogrids as manufactured by TenCate Geosynthetics.

2.03 GEOTEXTILE:

- A. Nonwoven geotextile fabric shall be placed as indicated on the retaining wall construction shop drawings. Additionally, the nonwoven geotextile fabric shall be placed in the v-shaped joint between adjacent block units on the same course. The nonwoven geotextile fabric shall meet the requirements Class 3 construction survivability in accordance with AASHTO M 288.
- B. Preapproved Nonwoven Geotextile Products:
 - 1. Mirafi 140N
 - 2. Propex Geotex 451
 - 3. Skaps GT-142
 - 4. Thrace-Linq 140EX
 - 5. Carthage Mills FX-40HS
 - 6. Stratatex ST 142

2.04 DRAINAGE AGGREGATE AND WALL INFILL:

- A. Drainage aggregate (and wall infill for retaining walls designed as modular gravity structures) shall be a durable crushed stone conforming to No. 57 size per ASTM C33 with the following particle-size distribution requirements per ASTM D422:

U.S. Standard	
Sieve Size	Passing
1 – 1-1/2 inches	100
1 inch	95-100
1/2 inch	25-60
No. 4	0-10
No. 8	0-2

2.05 REINFORCED FILL:

- A. Material used as reinforced backfill material in the reinforced zone (if applicable) shall be a granular fill material meeting the requirements of USCS soil type GW, GP, SW or

SP per ASTM D2487 or alternatively by AASHTO Group Classification A-1-a or A-3 per AASHTO M 145. The backfill shall exhibit a minimum effective internal angle of friction, $\phi = 34$ degrees at a maximum 2 percent shear strain and meet the following particle-size distribution requirements per ASTM D422.

U.S. Standard	
Sieve Size	Passing
3/4 inch	100
No. 4	0-100
No. 40	0-60
No. 200	0-15

- B. The reinforced backfill material shall be free of sod, peat, roots or other organic or deleterious matter including, but not limited to, ice, snow or frozen soils. Materials passing the No. 40 sieve shall have a liquid limit less than 25 and plasticity index less than 6 per ASTM D4318. Organic content in the backfill material shall be less than 1 percent per AASHTO T-267 and the pH of the backfill material shall be between 5 and 8.
- C. Soundness. The reinforced backfill material shall exhibit a magnesium sulfate soundness loss of less than 30 percent after four (4) cycles, or sodium sulfate soundness loss of less than 15 percent after five (5) cycles as measured in accordance with AASHTO T-104.
- D. Reinforced backfill shall not be comprised of crushed or recycled concrete, recycled asphalt, bottom ash, shale or any other material that may degrade, creep or experience a loss in shear strength or a change in pH over time.

2.06 LEVELING PAD:

- A. The precast modular block units shall be placed on a leveling pad constructed from crushed stone or unreinforced concrete. The leveling pad shall be constructed to the dimensions and limits shown on the retaining wall design drawings prepared by the Retaining Wall Design Engineer.
- B. Crushed stone used for construction of a granular leveling pad shall meet the requirements of the drainage aggregate and wall infill in Paragraph 2.04 or a preapproved alternate material.
- C. Concrete used for construction of an unreinforced concrete leveling pad shall satisfy the criteria for AASHTO Class B. The concrete should be cured a minimum of 12 hours prior to placement of the precast modular block wall retaining units and exhibit a minimum 28-day compressive strength of 2,500 psi.

2.07 DRAINAGE:

A. Drainage Pipe:

1. Drainage collection pipe shall be a 4-inch diameter, 3-hole perforated, HDPE pipe with a minimum pipe stiffness of 22 psi per ASTM D2412.
2. The drainage pipe shall be manufactured in accordance with ASTM D1248 for HDPE pipe and fittings.

B. Preapproved Drainage Pipe Products:

1. ADS 3000 Triple Wall pipe as manufactured by Advanced Drainage Systems.

2.08 UNIT ADHESIVES:

- A. Adhesive shall be a premium, construction grade suitable for concrete and exterior applications.

2.09 FINISHES:

- A. Finished retaining wall shall be stained in accordance with Section 09 93 13.13 "Exterior Staining".

1. Acceptable product stains:
 - a. Sherwin Williams H & C SHIELD PLUS CONCRETE STAIN
 - b. TK Products TRI-SHEEN PIGMENTED STAIN TK-5272
2. Color shall match building CMU Block and Clearwell exterior wall stain.

B. Graffiti Resistant Coatings

1. Acceptable sealers and anti-graffiti coatings
 - a. TK Products 1496 TK Perma-Clean OTC (anti-graffiti)

PART 3 - EXECUTION

3.01 GENERAL:

- A. All work shall be performed in accordance with OSHA safety standards, state and local building codes and manufacturer's requirements.
- B. The General Contractor is responsible for the location and protection of all existing underground utilities. Any new utilities proposed for installation in the vicinity of the retaining wall, shall be installed concurrent with retaining wall construction. The

General Contractor shall coordinate the work of subcontractors affected by this requirement.

- C. New utilities installed below the retaining wall shall be backfilled and compacted to a minimum of 98% maximum dry density per ASTM D698 standard proctor.
- D. The General Contractor is responsible to ensure that safe excavations and embankments are maintained throughout the course of the project.
- E. All work shall be inspected by the Inspection Engineer as directed by the Owner.
- F. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.

3.02 EXAMINATION:

- A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting short-term and long-term performance of segmental retaining walls.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 PREPARATION:

A. Fill Soil:

- 1. The Inspection Engineer shall verify that reinforced backfill placed in the reinforced soil zone satisfies the criteria of this section.
- 2. The Inspection Engineer shall verify that any fill soil installed in the foundation and retained soil zones of the retaining wall satisfies the specification of the Retaining Wall Design Engineer as shown on the Contract Drawings.

B. Excavation:

- 1. The Grading Contractor shall excavate to the lines and grades required for construction of the precast modular block retaining wall as shown on the construction drawings. The Grading Contractor shall minimize over-excavation. Excavation support, if required, shall be the responsibility of the Grading Contractor.
- 2. Over-excavated soil shall be replaced with compacted fill in conformance with the specifications of the Retaining Wall Design Engineer.
- 3. Embankment excavations shall be bench cut as directed by the project Geotechnical Engineer and inspected by the Inspection Engineer for compliance.

C. Foundation Preparation:

1. Prior to construction of the precast modular block retaining wall, the leveling pad area and undercut zone (if applicable) shall be cleared and grubbed. All topsoil, brush, frozen soil and organic material shall be removed. Additional foundation soils found to be unsatisfactory beyond the specified undercut limits shall be undercut and replaced with approved fill as directed by the project Geotechnical Engineer. The Inspection Engineer shall ensure that the undercut limits are consistent with the requirements of the project Geotechnical Engineer and that all soil fill material is properly compacted according to project specifications. The Inspection Engineer shall document the volume of undercut and replacement.
2. Following excavation for the leveling pad and undercut zone (if applicable), the Inspection Engineer shall evaluate the in-situ soil in the foundation and retained soil zones.
 - a. The Inspection Engineer shall verify that the shear strength of the in-situ soil assumed by the Retaining Wall Design Engineer is appropriate. The Inspection Engineer shall immediately stop work and notify the Owner if the in-situ shear strength is found to be inconsistent with the retaining wall design assumptions.
 - b. The Inspection Engineer shall verify that the foundation soil exhibits sufficient ultimate bearing capacity to satisfy the requirements indicated on the retaining wall construction shop drawings.

D. Leveling Pad:

1. The leveling pad shall be constructed to provide a level, hard surface on which to place the first course of precast modular block units. The leveling pad shall be placed in the dimensions shown on the retaining wall construction drawings and extend to the limits indicated.
2. Crushed Stone Leveling Pad. Crushed stone shall be placed in uniform maximum lifts of 6-inches. The crushed stone shall be compacted by a minimum of 3 passes of a vibratory compactor capable of exerting 2,000 pounds of centrifugal force and to the satisfaction of the Inspection Engineer.
3. Unreinforced Concrete Leveling Pad. The concrete shall be placed in the same dimensions as those required for the crushed stone leveling pad. The Retaining Wall Installation Contractor shall erect proper forms as required to ensure the accurate placement of the concrete leveling pad according to the retaining wall construction drawings.

3.04 PRECAST MODULAR BLOCK WALL SYSTEM INSTALLATION:

- A. The precast modular block structure shall be constructed in accordance with the construction drawings, these specifications and the recommendations of the retaining

wall system component manufacturers. Where conflicts exist between the manufacturer's recommendations and these specifications, these specifications shall prevail.

B. Drainage components. Pipe, geotextile and drainage aggregate shall be installed as shown on the construction shop drawings.

C. Precast Modular Block Installation:

1. The first course of block units shall be placed with the front face edges tightly abutted together on the prepared leveling pad at the locations and elevations shown on the construction drawings. The Retaining Wall Installation Contractor shall take special care to ensure that the bottom course of block units are in full contact with the leveling pad, are set level and true and are properly aligned according to the locations shown on the construction drawings.
2. Backfill shall be placed in front of the bottom course of blocks prior to placement of subsequent block courses. Nonwoven geotextile fabric shall be placed in the V-shaped joints between adjacent blocks. Drainage aggregate shall be placed in the V-shaped joints between adjacent blocks to a minimum distance of 12 inches behind the block unit.
3. Drainage aggregate shall be placed in 9 inch maximum lifts and compacted by a minimum of three (3) passes of a vibratory plate compactor capable exerting a minimum of 2,000 pounds of centrifugal force.
4. Unit core fill shall be placed in the precast modular block unit vertical core slot. The core fill shall completely fill the slot to the level of the top of the block unit. The top of the block unit shall be broom-cleaned prior to placement of subsequent block courses. No additional courses of precast modular blocks may be stacked before the unit core fill is installed in the blocks on the course below.
5. Base course blocks for gravity wall designs (without geosynthetic soil reinforcement) may be furnished without vertical core slots. If so, disregard item 4 above, for the base course blocks in this application.
6. Nonwoven geotextile fabric shall be placed between the drainage aggregate and the retained soil (gravity wall design) or between the drainage aggregate and the reinforced fill (reinforced wall design) as required on the retaining wall construction drawings.
7. Subsequent courses of block units shall be installed with a running bond (half block horizontal course-to-course offset). With the exception of 90 degree corner units, the shear channel of the upper block shall be fully engaged with the shear knobs of the block course below. The upper block course shall be pushed forward to fully engage the interface shear key between the blocks and to ensure consistent face batter and wall alignment. Geogrid, drainage aggregate, unit core fill,

geotextile and properly compacted backfill shall be complete and in-place for each course of block units before the next course of blocks is stacked.

8. The elevation of retained soil fill shall not be less than 1 block course below the elevation of the reinforced backfill throughout the construction of the retaining wall.
9. If included as part of the precast modular block wall design, cap units shall be secured with an adhesive in accordance with the precast modular block manufacturer's recommendation.

D. Geogrid Reinforcement Installation (if required):

1. Geogrid reinforcement shall be installed at the locations and elevations shown on the construction drawings on level fill compacted to the requirements of this specification.
2. Continuous 12 inches wide strips of geogrid reinforcement shall be passed completely through the vertical core slot of the precast modular block unit and extended to the embedment length shown on the construction plans. The strips shall be staked or anchored as necessary to maintain a taut condition.
3. Reinforcement length (L) of the geogrid reinforcement is measured from the back of the precast modular block unit. The cut length (Lc) is two times the reinforcement length plus additional length through the block facing unit. The cut length is calculated as follows:

$$L_c = 2 * L + 3 \text{ ft } (2 * L + 0.9 \text{ m}) \text{ (28" (710 mm) block unit)}$$

$$L_c = 2 * L + 5 \text{ ft } (2 * L + 1.5 \text{ m}) \text{ (41" (1030 mm) block unit)}$$

4. The geogrid strip shall be continuous throughout its entire length and may not be spliced. The geogrid shall be furnished in nominal, prefabricated roll widths of 12 inches, plus or minus 1/2 inch. No field modification of the geogrid roll width shall be permitted.
5. Neither rubber tire nor track vehicles may operate directly on the geogrid. Construction vehicle traffic in the reinforced zone shall be limited to speeds of less than 5 mph once a minimum of 9 inches of compacted fill has been placed over the geogrid reinforcement. Sudden braking and turning of construction vehicles in the reinforced zone shall be avoided.

E. Construction Tolerance. Allowable construction tolerance of the retaining wall shall be as follows:

1. Deviation from the design batter and horizontal alignment, when measured along a 10-foot straight wall section, shall not exceed 3/4 inches.

2. Deviation from the overall design batter shall not exceed 1/2 inch per 10-feet of wall height.
3. The maximum allowable offset (horizontal bulge) of the face in any precast modular block joint shall be 1/2 inch.
4. The base of the precast modular block wall excavation shall be within 2 inches of the staked elevations, unless otherwise approved by the Inspection Engineer.
5. Differential vertical settlement of the face shall not exceed 1-foot along any 200-feet of wall length.
6. The maximum allowable vertical displacement of the face in any precast modular block joint shall be 1/2 inch.
7. The wall face shall be placed within 2 inches of the horizontal location staked.

3.05 WALL INFILL AND REINFORCED BACKFILL PLACEMENT:

- A. Backfill material placed immediately behind the drainage aggregate shall be compacted as follows:
 1. 98 percent of maximum dry density at plus or minus 2 percent optimum moisture content per ASTM D698 standard proctor or 85 percent relative density per ASTM D4254.
- B. Compactive effort within 3-feet of the back of the precast modular blocks should be accomplished with walk-behind compactors. Compaction in this zone shall be within 95 percent of maximum dry density as measured in accordance with ASTM D698 standard proctor or 80 percent relative density per ASTM D 4254. Heavy equipment should not be operated within 3-feet of the back of the precast modular blocks.
- C. Backfill material shall be installed in lifts that do not exceed a compacted thickness of 9-inches.
- D. At the end of each work day, the Retaining Wall Installation Contractor shall grade the surface of the last lift of the granular wall infill to a 3 percent, plus or minus 1 percent slope away from the precast modular block wall face and compact it.
- E. The General Contractor shall direct the Grading Contractor to protect the precast modular block wall structure against surface water runoff at all times through the use of berms, diversion ditches, silt fence, temporary drains and/or any other necessary measures to prevent soil staining of the wall face, scour of the retaining wall foundation or erosion of the reinforced backfill or wall infill.

3.06 OBSTRUCTIONS IN THE INFILL AND REINFORCED FILL ZONE:

- A. The Retaining Wall Installation Contractor shall make all required allowances for obstructions behind and through the wall face in accordance with the approved construction shop drawings.
- B. Should unplanned obstructions become apparent for which the approved construction shop drawings do not account, the affected portion of the wall shall not be constructed until the Retaining Wall Design Engineer can appropriately address the required procedures for construction of the wall section in question.

3.07 COMPLETION:

- A. For walls supporting unpaved areas, a minimum of 12-inch of compacted, low-permeability fill shall be placed over the granular wall infill zone of the precast modular block retaining wall structure. The adjacent retained soil shall be graded to prevent ponding of water behind the completed retaining wall.
- B. For retaining walls with crest slopes of 5H:1V or steeper, silt fence shall be installed along the wall crest immediately following construction. The silt fence shall be located 3-feet to 4-feet behind the uppermost precast modular block unit. The crest slope above the wall shall be immediately seeded to establish vegetation. The General Contractor shall ensure that the seeded slope receives adequate irrigation and erosion protection to support germination and growth.
- C. The General Contractor shall confirm that the as-built precast modular block wall geometries conform to the requirements of this section. The General Contractor shall notify the Owner of any deviations.

3.08 CONSTRUCTION TOLERANCES:

- A. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet, 3 inches maximum.
- B. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet.
- C. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet.

3.09 FIELD QUALITY CONTROL:

- A. Comply with requirements in Section 31 22 00 for field quality control.
 - 1. In each compacted backfill layer, perform at least 1 field in-place compaction test for each 100 feet or less of segmental retaining wall length.

2. In each compacted backfill layer, perform at least 1 field in-place compaction test for each 24 inches of fill depth and each 50 feet or less of segmental retaining wall length.

3.10 ADJUSTING:

- A. Remove and replace retaining wall construction of the following descriptions:
 1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Engineer approves methods and results.
 2. Segmental retaining walls that do not match approved Samples and mockups.
 3. Segmental retaining walls that do not comply with other requirements indicated.
- B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

3.11 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 32 84 00
PLANTING IRRIGATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.

B. Related Requirements:

1. Section 220519 "Meters and Gages for Plumbing Piping" for water metering requirements.
2. Section 230923.14 "Flow Instruments" for water metering equipment.

1.02 DEFINITIONS

- A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

- B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
- C. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
- D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.03 ACTION SUBMITTALS

A. Product Data:

1. Pipes, tubes, and fittings.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.
15. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

- ##### A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are indicated and coordinated with each other, using input from Installers of the items

involved. Also include adjustments necessary to avoid plantings and obstructions, such as signs and light standards.

- B. Zoning Chart: Indicate each irrigation zone and its control valve.
- C. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- D. Field Quality-Control Submittals:
 - 1. Field quality-control reports.
- E. Qualification Statements: For Installer.
- F. Delegated design engineer qualifications.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sprinklers controllers and] automatic control valves to include in operation and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spray Sprinklers: Equal to 10 percent of amount installed for each type and size indicated, but no fewer than 1 unit.
 - 2. Bubblers: Equal to 10 percent of amount installed for each type indicated, but no fewer than 3 units.
 - 3. Emitters: Equal to 10 percent of amount installed for each type indicated, but no fewer than 10 units.
 - 4. Drip-Tube System Tubing: Equal to 10 percent of total length installed for each type and size indicated, but not less than 50 ft.
 - 5. Soaker Tubes: Equal to 10 percent of total length installed for each type and size indicated, but not less than 50 ft.
- B. Schedule of maintenance material items.

1.07 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Installers: Entity that employs a Certified Irrigation Designer - Landscape qualified by the Irrigation Association.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and entrance of dirt, debris, and moisture.
- B. Store plastic piping protected from direct sunlight. Support piping to prevent sagging and bending.

1.09 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than three days in advance of proposed interruption of water service.
 - 2. Do not proceed with interruption of water service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Irrigation Zone Control: Automatic operation with controller and automatic control valves.
- B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions, such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.
- C. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
 - 1. Irrigation Main Piping: 60 psig min.
 - 2. Circuit Piping: 45 psig min.

2.02 PIPES, TUBES, AND FITTINGS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

- B. Galvanized-Steel Pipe: ASTM A53/A53M, Standard Weight, Type E, Grade B.
 - 1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Standard Weight, seamless-steel pipe with threaded ends.
 - 2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
 - 3. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
 - 4. Cast-Iron Flanges: ASME B16.1, Class 125.
- C. Hard Copper Tube: ASTM B88, Type K water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- D. ASME Seamless Red Brass Pipe: ASTM B43, Strong Class, O61 annealed
 - 1. Threaded nipples shall conform to ASME B1.20.1.
 - 2. Cast Threaded Joint Fittings: Cast bronze per ASTM B62, ASME B16.15. Threads adhering to ASME B1.20.1.
 - 3. Unions: Brass bodies per ASTM B16
- E. PE Pipe with Controlled ID: ASTM D2239, PE 3408 compound; SIDR 11.5 and SIDR 15.
 - 1. Insert Fittings for PE Pipe: ASTM D2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.
- F. PE Pipe with Controlled OD: ASTM D3035, PE 3408 compound, SIDR 11.
 - 1. PE Butt, Heat-Fusion Fittings: ASTM D3261.
 - 2. PE Socket-Type Fittings: ASTM D2683.
- G. PE Pressure Pipe: AWWA C906, with DR of 7.3, 9, or 9.3 and PE compound number required to give pressure rating of not less than 200 psig.
 - 1. PE Butt, Heat-Fusion Fittings: ASTM D3261.
 - 2. PE Socket-Type Fittings: ASTM D2683.

- H. PVC Pipe: ASTM D1785, PVC 1120 compound, Schedule 40.
 - 1. PVC Socket Fittings: ASTM D2466, Schedule 40.
 - 2. PVC Threaded Fittings: ASTM D2464, Schedule 80.
 - 3. PVC Socket Unions: Construction similar to that of MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.
- I. PVC Pipe, Pressure Rated: ASTM D2241, PVC 1120 compound, SDR 21 and SDR 26.
 - 1. PVC Socket Fittings: ASTM D2467, Schedule 80.
 - 2. PVC Socket Unions: Construction similar to that of MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.03 PIPING JOINING MATERIALS

- A. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer in accordance with ASTM F656.
- B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.04 MANUAL VALVES

- A. Brass Ball Valves:
 - 1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded or solder joint if indicated.
 - g. Seats: PTFE or TFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

B. Plastic Ball Valves:

1. Description:

- a. Standard: MSS SP-122.
- b. Pressure Rating: 125 psig minimum 150 psig.
- c. Body Material: PVC.
- d. Type: Union.
- e. End Connections: Socket or threaded.
- f. Port: Full.

2.05 PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Description:

- a. Standard: ASSE 1003.
- b. Body Material: Bronze for NPS 2 and smaller.
- c. Pressure Rating: Initial pressure of 150 psig.
- d. End Connections: Threaded for NPS 2 and smaller.

2. Capacities and Characteristics:

- a. Size: 1-1/2" NPS.
- b. Design Flow Rate: 20 gpm.
- c. Design Inlet Pressure: 60 - 120 psig.
- d. Design Outlet Pressure Setting: 50 psig.

2.06 AUTOMATIC CONTROL VALVES

A. Plastic, Automatic Control Valves:

- 1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24 V ac solenoid.

2.07 TRANSITION FITTINGS

- A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
- B. Transition Couplings:
 - 1. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.
- C. Plastic-to-Metal Transition Fittings:
 - 1. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket or threaded end.
- D. Plastic-to-Metal Transition Unions:
 - 1. Description: MSS SP-107, PVC four-part union. Include one brass or stainless steel threaded end, one solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

2.08 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions:
 - 1. Description: Factory-fabricated union, NPS 2 and smaller.
 - a. Pressure Rating: 150 psig minimum at 180 deg F.
 - b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
- C. Dielectric Couplings:
 - 1. Description: Galvanized-steel coupling.
 - a. Pressure Rating: 300 psig at 225 deg F.
 - b. End Connections: Female threaded.
 - c. Lining: Inert and noncorrosive, thermoplastic lining.
- D. Dielectric Nipples:

1. Description: Electroplated steel nipple complying with ASTM F1545.

a. Pressure Rating: 300 psig at 225 deg F.

b. End Connections: Male threaded or grooved.

c. Lining: Inert and noncorrosive, propylene.

2.09 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.

B. Pressure Gages: ASME B40.1. Include 2-1/2-inch diameter dial, dial range of two times system operating pressure, and bottom outlet.

2.10 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.

B. Plastic, Pop-up Spray Sprinklers:

1. Description:

a. Body Material: ABS.

b. Nozzle: ABS.

c. Retraction Spring: Stainless steel.

d. Internal Parts: Corrosion resistant.

e. Pattern: Fixed, with flow adjustment.

2.11 QUICK COUPLERS

A. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

2.12 DRIP IRRIGATION SPECIALTIES

A. Freestanding Emitters: Device to deliver water at approximately 20 psig.

1. Body Material: PE or vinyl, with flow control.

2. Riser to Emitter: PE or PVC flexible tubing.

B. Multiple-Outlet Emitter Systems: Emitter with tubing and button-type outlets.

1. Emitter: With multiple outlets to deliver water to remote outlets.

- a. Body Material: Plastic, with flow control.
- b. Outlet Caps: Plastic, for outlets without installed tubing.
- c. Operation: Automatic pressure compensating.
- d. Emitters: Devices to deliver water at approximately 20 psig

C. Drip Tubes with Direct-Attached Emitters:

- 1. Tubing: Flexible PE with plugged end.
- 2. Emitters: Devices to deliver water at approximately 20 psig.
 - a. Body Material: PE or vinyl, with flow control.
 - b. Mounting: Inserted into tubing at set intervals.

D. Drip Tubes with Remote Discharge:

- 1. Tubing: Flexible PE or PVC with plugged end.
- 2. Emitters: Devices to deliver water at approximately 20 psig.
 - a. Body Material: PE or vinyl, with flow control.
 - b. Mounting: Inserted into tubing at set intervals.

E. Application Pressure Regulators: Plastic housing, NPS 3/4, with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig.

F. Filter Units: Plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.

G. Air Relief Valves: Plastic housing, with corrosion-resistant internal parts.

H. Vacuum Relief Valves: Plastic housing, with corrosion-resistant internal parts.

2.13 CONTROLLERS

A. Description:

- 1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 120 minutes. Include switch for manual or automatic operation of each station.

2. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and two matching keys.
 - a. Body Material: Molded plastic.
 - b. Mounting: Surface type for wall.
3. Control Transformer: 24 V secondary, with primary fuse.
4. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.
 - a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
 - b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
 - c. Surge Protection: Metal-oxide-varistor type on each station and primary power.
5. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
6. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
 - a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
 - c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

2.14 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
 - a. Size: As required for valves and service.

- b. Shape: Round Rectangular.
 - c. Sidewall Material: ABS.
 - d. Cover Material: ABS.
- B. Drainage Backfill: See drawing details.

PART 3 - EXECUTION

3.01 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
- B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.
- C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches, to 12 inches below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.
- D. Provide minimum cover over top of underground piping according to the following:
 - 1. Irrigation Main Piping: Minimum depth of 18 inches below finished grade measured to the top of the pipe.
 - 2. Lateral Piping: 12 inches to the top of the pipes.
 - 3. Drain Piping: 12 inches to the top of the pipes.
 - 4. Sleeves: Match the depth of the type of pipe being sleeved.

3.02 PREPARATION

- A. Set stakes to identify locations of proposed irrigation system. Obtain Landscape Architect's approval before excavation.

3.03 INSTALLATION OF PIPING

- A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.
- G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 or larger pipe connection.
- H. Install PVC piping in dry weather when temperature is above 40 deg F. Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.
- I. Install piping in sleeves under parking lots, roadways, and sidewalks.
- J. Install sleeves made of Schedule 40, PVC pipe and socket fittings, and solvent-cemented joints.
- K. Install transition fittings for plastic-to-metal pipe connections according to the following:
 - 1. Underground Piping:
 - a. NPS 1-1/2 and Smaller: Plastic-to-metal transition fittings.
 - b. NPS 2 and Larger: AWWA transition couplings.
 - 2. Aboveground Piping:
 - a. NPS 2 and Smaller: Plastic-to-metal transition fittings.
 - b. NPS 2 and Larger: Use dielectric flange kits with one plastic flange.

3.04 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners in accordance with piping manufacturer's written instructions.

- E. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join in accordance with ASTM D2657.
 - 1. Plain-End PE Pipe and Fittings: Use butt fusion.
 - 2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
- F. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Pressure Piping: Join schedule number, ASTM D1785, PVC pipe and PVC socket fittings in accordance with ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings in accordance with ASTM D2855.
 - 3. PVC Nonpressure Piping: Join in accordance with ASTM D2855.

3.05 INSTALLATION OF VALVES

- A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.
- B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.
 - 1. Install valves and PVC pipe with restrained, gasketed joints.
- C. Aboveground Valves: Install as components of connected piping system.
- D. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves.
- E. Throttling Valves: Install in underground piping in boxes for automatic control valves.
- F. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.06 INSTALLATION OF SPRINKLERS

- A. Install sprinklers after hydrostatic test is completed.
- B. Install sprinklers at manufacturer's recommended heights.
- C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.07 INSTALLATION OF DRIP IRRIGATION SPECIALTIES

- A. Install freestanding emitters on pipe riser to mounting height indicated.

- B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.
- C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.
- D. Install drip tubes with direct-attached emitters on ground.
- E. Install drip tubes with remote discharge on ground with outlets on off-ground supports at height indicated.
- F. Install off-ground supports of length required for indicated mounted height of device.
- G. Install application pressure regulators and filter units in piping near device being protected, and in control-valve boxes.

3.08 INSTALLATION OF AUTOMATIC IRRIGATION CONTROL SYSTEM

- A. Equipment Mounting, Interior: Install controllers on interior wall.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Equipment Mounting, Exterior: Install exterior freestanding controllers on precast concrete bases.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Install control cable in same trench as irrigation piping and at least beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.09 CONNECTIONS

- A. Comply with requirements for piping specified in Section 331415 "Site Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

- C. Connect wiring between controllers and automatic control valves.

3.10 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
 - 1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.11 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Irrigation system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.12 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that controllers are installed and connected in accordance with the Contract Documents.
 - 3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.13 ADJUSTING

- A. Adjust settings of controllers.
- B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.
- C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.

3.14 CLEANING

- A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.15 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.

3.16 PIPING SCHEDULE

- A. Install components having pressure rating equal to or greater than system operating pressure.
- B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.
- C. Underground Irrigation Main Piping:
 - 1. NPS 4 and Smaller:
 - a. NPS 4 PE pressure pipe; PE butt, heat-fusion or socket-type fittings; and heat-fusion joints.
 - b. Schedule 40, PVC pipe and socket fittings, and solvent-cemented joints.
 - c. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
 - d. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
- D. Lateral Piping:
 - 1. NPS 1 and Smaller:
 - a. DR 9, PE, controlled OD pipe; PE butt, heat-fusion, or PE socket-type fittings; and heat-fusion joints.

- b. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
- E. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.
 - 1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.
- F. Risers to Aboveground Sprinklers and Specialties:
 - 1. Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.
- G. Drain piping shall be one of the following:
 - 1. SDR 9, 11.5, or 15; PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
 - 2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
 - 3. SDR 21, 26, or 32.5; PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

3.17 VALVE SCHEDULE

- A. Underground, Shutoff-Duty Valves: Use the following:
 - 1. NPS 2 and Smaller: Curb valve, curb-valve casing, and shutoff rod.
- B. Aboveground, Shutoff-Duty Valves:
 - 1. NPS 2 and Smaller:
 - a. Brass ball valve.
- C. Drain Valves:
 - 1. NPS 1/2 and NPS 3/4:
 - a. Brass ball valve.
 - 2. NPS 1 to NPS 2:
 - a. Brass ball valve.

END OF SECTION

SECTION 32 91 13

SOIL PREPARATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section includes planting soils and layered soil assemblies specified by composition of the mixes.
- B. Related Requirements:
 - 1. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
 - 2. Section 329300 "Plants" for placing planting soil for plantings.

1.03 DEFINITIONS

- A. AAPFCO: Association of American Plant Food Control Officials.
- B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.
- C. CEC: Cation exchange capacity.
- D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.
- E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.
- F. Imported Soil: Soil that is transported to Project site for use.
- G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.
- H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

- I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.
- J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."
- K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.
- M. SSSA: Soil Science Society of America.
- N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- Q. USCC: U.S. Composting Council.

1.04 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.05 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include recommendations for application and use.
 - 2. Include test data substantiating that products comply with requirements.
 - 3. Include sieve analyses for aggregate materials.
 - 4. Material Certificates: For each type of soil amendment and fertilizer before delivery to the site.

1.06 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.07 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.
 - 1. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.08 SOIL-SAMPLING REQUIREMENTS

- A. General: Extract soil samples according to requirements in this article.
- B. Sample Collection and Labeling: Have samples taken and labeled by Contractor in presence of Landscape Architect under the direction of the testing agency.
 - 1. Number and Location of Samples: Minimum of three representative soil samples from varied locations within planting areas shown on the drawings for each soil to be used or amended for landscaping purposes.
 - 2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils.
 - 3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its their records.
 - 4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.09 TESTING REQUIREMENTS

- A. General: Perform tests on soil samples according to requirements in this article.
- B. Physical Testing:
 - 1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
 - a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.

- b. Hydrometer Method: Report percentages of sand, silt, and clay.
 - 2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
 - 3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
 - 4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D698 (Standard Proctor).
- C. Chemical Testing:
- 1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
 - 2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
 - 3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
- D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of SSSA NAPT WERA-103, including the following:
- 1. Percentage of organic matter.
 - 2. CEC, calcium percent of CEC, and magnesium percent of CEC.
 - 3. Soil reaction (acidity/alkalinity pH value).
 - 4. Buffered acidity or alkalinity.
 - 5. Nitrogen ppm.
 - 6. Phosphorous ppm.
 - 7. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
 - 8. Other deleterious materials, including their characteristics and content of each.
- E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3 - Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. for 6-inch depth of soil.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inch depth of soil.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.01 PLANTING SOILS SPECIFIED BY COMPOSITION

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Planting-Soil Type: Imported, naturally formed soil from off-site sources and consisting of sandy loam soil according to USDA textures; and modified to produce viable planting soil.

1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches deep, not from bogs, or marshes;

and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants.

2. Additional Properties of Imported Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 4 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
3. Unacceptable Properties: Clean soil of the following:
 - a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
4. Amended Soil Composition: Blend imported, unamended soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Soil: 1:3 by volume.

C. Planting-Soil Type: Manufactured soil consisting of manufacturer's basic topsoil, blended in a manufacturing facility with sand, stabilized organic soil amendments, and other materials to produce viable planting soil.

1. Additional Properties of Manufacturer's Basic Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 4 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
2. Unacceptable Properties: Manufactured soil shall not contain the following:
 - a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of [5] <Insert number> percent by dry weight of the manufactured soil.
3. Blend manufacturer's basic soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Soil: 1:3 by volume.

2.02 INORGANIC SOIL AMENDMENTS

- A. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- B. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33/C33M.

2.03 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
 - 1. Feedstock: May include sewage sludge.
 - 2. Reaction: 2 pH of 5.5 to 8.
 - 3. Soluble-Salt Concentration: Less than 4 dS/m.
 - 4. Moisture Content: 35 to 55 percent by weight.
 - 5. Organic-Matter Content: 30 to 40 percent of dry weight.
 - 6. Particle Size: Minimum of 98 percent passing through a 1-inch sieve.
- B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.
- C. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
 - 1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

2.04 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.
- C. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.01 GENERAL

- A. Place planting soil and fertilizers according to requirements in other Specification Sections.
- B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.
- C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.02 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

- A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
- C. Mixing: Spread unamended soil to total depth of 6 inches, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
 - 1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
 - a. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- D. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.03 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

- A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
- C. Application: Spread planting soil to total depth of 6 inches, but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
1. Lifts: Apply planting soil in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- D. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.04 BLENDING PLANTING SOIL IN PLACE

- A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of 6 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
- C. Mixing: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.
1. Mix fertilizer with planting soil no more than seven days before planting.

- D. Compaction: Compact blended planting soil to 80 percent of maximum Standard Proctor density according to ASTM D698.
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.05 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

- A. Application: Apply compost component of planting-soil to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.06 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests:
 - 1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. Space tests at no less than one for each 1000 sq. ft. of in-place soil or part thereof.
- C. Soil will be considered defective if it does not pass tests.
- D. Prepare test and inspection reports.
- E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.07 PROTECTION

- A. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Vehicle traffic.
 - 4. Foot traffic.

5. Erection of sheds or structures.
 6. Impoundment of water.
 7. Excavation or other digging unless otherwise indicated.
- B. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Landscape Architect and replace contaminated planting soil with new planting soil.
- 3.08 CLEANING
- A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

END OF SECTION

SECTION 32 92 00
TURF AND GRASSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:

- 1. Seeding.
- 2. Hydroseeding.
- 3. Sodding.

- B. Related Requirements:

- 1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.

1.03 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.
- E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
- C. Product Certificates: For fertilizers, from manufacturer.
- D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.05 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or American Horticultural Society.
 - 2. Experience: Five years' experience in turf installation in addition to requirements in Section 01 40 00 "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the National Association of Landscape Professionals:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Lawn Care Manager.
 - c. Landscape Industry Certified Lawn Care Technician.
 - 5. Pesticide Applicator: State licensed, commercial.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.
- C. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk materials with appropriate certificates.

1.08 FIELD CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
 - 1. Spring Planting: March 15th to June 15th.
 - 2. Fall Planting: September 15th to December 15th.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions. No planting shall occur when soil temperatures are below 30° F.

PART 2 - MATERIALS

2.01 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species:

1. Quality, State Certified: State-certified seed of grass species as listed below for solar exposure.
 2. Full Sun, Cool-Season Grass: Tall Fescue (Festuca arundinacea), a minimum of three cultivars.
- C. Grass-Seed Mix: Proprietary seed mix as follows:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work with include, but are not limited to, the following with approval from the Landscape Architect:
 - a. Granite Seed Company "Triple Play Blend" turfgrass fescue blend.

2.02 TURFGRASS SOD

- A. Turfgrass Sod: Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species, Warm-Season Grass: Turf-type tall fescue (Festuca arundinacea), shade tolerant blend. There shall be a minimum of three cultivars present.

2.03 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 1. Composition:
 - a. 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.04 PESTICIDES

- A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.05 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 3. Uniformly moisten excessively dry soil that is not workable or which is dusty.
 - 4. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.02 PREPARATION

- A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.03 TURF AREA PREPARATION

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation. "Coordinate "Placing Planting Soil" Paragraph below with Section 329113 "Soil Preparation".
- B. Placing Planting Soil: Place and mix planting soil in place over exposed subgrade.
 - 1. Reduce elevation of planting soil to allow for soil thickness of sod.
- C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.04 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, commercial fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
 - 2. Spray-apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.05 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across slopes exceeding 1:3.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.06 TURF MAINTENANCE

- A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow turf-type tall fescue to a height of 2 to 3 inches.
- D. Turf Postfertilization: Apply commercial fertilizer after initial mowing and when grass is dry.
 - 1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.07 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 - 1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.

2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
 3. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
 4. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.
- B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.08 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.09 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.
- C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- D. Remove nondegradable erosion-control measures after grass establishment period.

3.10 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
1. Seeded Turf: 60 days from date of planting completion.

- a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
2. Sodded Turf: 30 days from date of planting completion.

END OF SECTION

SECTION 32 93 00

PLANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Plant materials.
2. Fertilizers.
3. Weed-control barriers.
4. Mulches.
5. Herbicides and pesticides.
6. Tree-stabilization materials.
7. Landscape edgings.
8. Tree grates.
9. Tree-watering devices.

B. Related Requirements:

1.02 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports: Percolation tests for tree pits. Include the following:

1. Tree identification number matching the plans.
2. Date of test.
3. Time when water was added to tree pit to start percolation test.
4. Time with photo documentation showing increments of testing with water level in tree pit.
5. Identification of tester.

B. Qualification Statements: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include

project names, addresses, and year completed, and include names and addresses of owners' contact persons.

- C. Product Certificates: For each type of manufactured product, from manufacturer, and complying with manufacturer's certified analysis of standard products.
- D. Pesticides and Herbicides: Product label and manufacturer's written application instructions specific to Project.
- E. Plants: Submit list of suppliers that will be used for the project to ensure that plant materials supplied are available in sufficient quantity and quality.

1.03 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.04 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
 - 1. Professional Membership: Member in good standing of either the National Association of Landscape Professionals or American Horticultural Society.
 - 2. Experience: Five years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
 - 3. Installer's Field Supervision: Maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certification: Installer's field supervisor certified in at least one of the following categories from the National Association of Landscape Professionals:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Horticultural Technician.
 - 5. Pesticide Applicator: State licensed, commercial.
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
- C. Measurements: Measure in accordance with ANSI Z60.1. Do not prune to obtain required sizes.
 - 1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-

grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Landscape Architect of sources of planting materials ten days in advance of delivery to site.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, or walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. Store bulbs, corms, and tubers in a dry place at 60° to 65° F until planting.

F. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

G. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Set balled and burlap stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
2. Do not remove container-grown stock from containers before time of planting.
3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.06 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: March 15th to June 15th.
2. Fall Planting: September 15th to December 15th.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions in accordance with manufacturer's written instructions and warranty requirements. No planting shall occur when soil temperatures are below 30° F.

1.07 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
 - b. Structural failures, including plantings falling or blowing over.
 - c. Faulty performance of tree stabilization.

2. Warranty Periods: Twelve months from the time of landscape project completion and acceptance.
 - a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
 - b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
3. Include the following remedial actions as a minimum:
 - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.01 PLANT MATERIALS

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
 1. Trees with damaged, crooked, or multiple leaders; with tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); with crossing trunks; with cut-off limbs more than 5/8 inch in diameter; or with stem girdling roots are unacceptable.
 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare in accordance with ANSI Z60.1.
- D. Labeling: Label at least 30% of the plants of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific

name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for plant.

- E. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.02 FERTILIZERS

- A. Granular Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

- 1. Composition:

- a. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- B. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per pound of vesicular-arbuscular mycorrhizal fungi and 95 million spores per pound of ectomycorrhizal fungi, 33 percent hydrogel, and maximum of 5.5 percent inert material.

2.03 WEED-CONTROL BARRIERS

- A. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd.

2.04 2.4 MULCHES

- A. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1-inch sieve; soluble-salt content of 3 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

- 1. Organic Matter Content: 50 percent of dry weight minimum.
- 2. Feedstock: Agricultural, or food; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

- B. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:

- 1. Type: (See design drawings)
- 2. Size Range: (See design drawings)
- 3. Color: (See design drawings)

2.05 HERBICIDES AND PESTICIDES

- A. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- B. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.
- C. Pesticides: Registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended in writing by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.06 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

- 1. Upright and Guy Stakes: Rough-sawn, sound, new softwood with pressure-preservative treatment, free of knots, holes, cross grain, and other defects.
- 2. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or upright posts.
- 3. Guys and Tie Wires: ASTM A641/A641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
- 4. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
- 5. Guy Cables: Five-strand, 3/16-inch-diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches long, with two 3/8-inch galvanized eyebolts.
- 6. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

B. Root-Ball Stabilization Materials:

- 1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated; stakes pointed at one end.
- 2. Wood Screws: ASME B18.6.1.

2.07 LANDSCAPE EDGINGS

- A. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B221, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.

1. Edging Size: 3/16 inch thick by 5-1/2 inches deep.
2. Stakes: Aluminum, ASTM B221, Alloy 6061-T6, approximately 1-1/2 inches wide by 12 inches long.
3. Finish: Manufacturer's standard.
 - a. Paint Color: Brown.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
 3. Suspend planting operations during periods of excessive soil moisture until moisture content reaches acceptable levels to attain required results.
 4. Uniformly moisten excessively dry soil that is not workable, or which is dusty.
- B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove soil and contamination as directed by Landscape Architect and replace with new planting soil.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.03 PLANTING AREA ESTABLISHMENT

- A. General: Prepare planting area for soil placement and mix planting soil in accordance with Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade.
- C. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- D. Application of Mycorrhizal Fungi: At time directed by Landscape Architect, broadcast dry product uniformly over prepared soil at application rate in accordance with manufacturer's written instructions.

3.04 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits.
 - 1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
 - 2. Excavate approximately two times as wide as ball diameter for balled and burlapped stock.
 - 3. Do not excavate deeper than depth of root ball, measured from the root flare to the bottom of root ball.
 - 4. If area under the plant was initially dug too deep, add soil to raise it to correct level and thoroughly tamp the added soil to prevent settling.
 - 5. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
 - 6. Maintain supervision of excavations during working hours.
 - 7. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
- B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated. Backfill soil shall be treated as described in the drawing details.

- C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
- D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
- E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.05 TREE, SHRUB, AND VINE PLANTING

- A. Inspection: At time of planting, verify that root flare is visible at top of root ball in accordance with ANSI Z60.1. If root flare is not visible, remove soil in a level manner from root ball to where the top-most root emerges from the trunk. After soil removal to expose root flare, verify that root ball still meets size requirements.
- B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
 - 1. Backfill: Planting drawing details 99-L704.
 - 2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 - 3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 - 4. Distribute fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
 - a. Quantity: Per manufacturer guidelines.
 - 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
 - 1. Backfill: Planting drawing details 99-L704.
 - 2. Carefully remove root ball from container without damaging root ball or plant.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. Fabric Bag-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
1. Backfill: Planting drawing details 99-L704.
 2. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 4. Distribute granular fertilizer around each planting pit when pit is approximately one-half filled. Do not place in bottom of the hole.
 5. Continue backfilling process. Water again after placing and tamping final layer of soil.
- F. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of root ball.
- 3.06 TREE, SHRUB, AND VINE PRUNING
- A. Prune, thin, and shape trees, shrubs, and vines in accordance with standard professional horticultural and arboricultural practices. Unless otherwise indicated by Landscape Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
 - B. Do not apply pruning paint to wounds.
- 3.07 INSTALLATION OF TREE-STABILIZATION MATERIALS
- A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:
 1. Upright Staking and Tying:

- a. Stake trees with two stakes for trees up to 12 ft high and 2-1/2 inches or less in caliper; three stakes for trees less than 14 ft. high and up to 4 inches in caliper. Space stakes equally around trees.
2. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
3. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
4. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.
 - a. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - b. Support trees with guy cable or multiple strands of tie wire, connected to brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - c. Attach flags to each guy wire, 30 inches above finish grade.
5. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and in accordance with manufacturer's written instructions.

3.08 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and vines 24 inches apart in even rows with triangular spacing.
- B. Dig holes large enough to allow spreading of roots.
- C. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to depth not less than two nodes.
- D. Work soil around roots to eliminate air pockets and leave slight saucer indentation around plants to hold water.
- E. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- F. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.09 INSTALLATION OF MULCHES

- A. Install weed-control barriers before mulching in accordance with manufacturer's written instructions. Completely cover area to be mulched, overlapping edges minimum of 6 inches, and secure seams with galvanized pins.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Mineral Mulch in Planting Areas: Apply 3-inch average thickness of mineral mulch over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 6 inches of trunks or stems.

3.10 INSTALLATION OF LANDSCAPE EDGINGS

- A. Aluminum Edging: Install aluminum edging where indicated in accordance with manufacturer's written instructions. Anchor with aluminum stakes spaced approximately 36 inches apart, driven below top elevation of edging.

3.11 APPLICATION OF HERBICIDES AND PESTICIDES

- A. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written instructions. Do not apply to seeded areas.
- B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written instructions.
- C. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and in accordance with manufacturer's written instructions. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

3.12 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.
- B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
- C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.13 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform tree pit percolation tests.
2. Tree pit construction will be considered defective if it does not pass percolation tests and inspections.
3. Do not proceed with planting in tree pits until satisfactory percolation is demonstrated.

B. Prepare test and inspection reports.

3.14 REPAIR AND REPLACEMENT

A. Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Landscape Architect.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Landscape Architect.

B. Remove and replace trees that are more than 25 percent dead or in unhealthy condition or are damaged during construction operations that Landscape Architect determines are incapable of restoring to normal growth pattern.

1. Provide new trees of same size as those being replaced for each tree of 4 inches or smaller in caliper size.
2. Species of Replacement Trees: Same species being replaced.

3.15 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

- D. After installation and before [**Substantial Completion**] <Insert time>, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

END OF SECTION

SECTION 33 10 00

WATER UTILITIES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide water utilities beyond 5 feet from buildings as indicated and in compliance with Contract Documents.
- B. Section includes:
 - 1. Pipe and fittings for the Provo River Water Treatment Plant and associated water utilities including raw water delivery and finished water in the transmission system, fire water line, fire hydrant and piping, and domestic water line.
- C. Excluded from this section are:
 - 1. Water utilities within 5 feet from buildings and within vaults. Refer to Division 22 for plumbing piping and Division 40 for process mechanical piping.
 - 2. Ductile Iron Water Pipe and Fittings refer to Section 40 23 19.04.
 - 3. AWWA C200 Fabricated Steel Pipe and Fittings refer to Section 40 23 19.03.
- D. All pipe, fittings, valves, couplings, and accessories specified herein shall be NSF 61 certified for use with water systems.

1.02 REFERENCES:

- A. American National Standards Institute (ANSI):
 - 1. NSF Std 61: Drinking Water System Components - Health Effects
 - 2. NSF Std 372: Drinking Water System Components - Lead Content
- B. American Society of Mechanical Engineers (ASME):
 - 1. B16.1: Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
 - 2. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
 - 3. B16.22: Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- C. ASTM International (ASTM):
 - 2. B88: Standard Specification for Seamless Copper Water Tube.

D. American Welding Society (AWS):

1. A5.8/A5.8M: Specification for Filler Metals for Brazing and Braze Welding.

E. American Water Works Association (AWWA):

10. C502/502a: Dry Barrel Fire Hydrants.
11. C504: Rubber Seated Butterfly Valves.
12. C515: Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
13. C550: Protective Interior Coatings for Valves and Hydrants.
14. C600: Installation of Ductile-Iron Water Mains and Their Appurtenances.

F. Factory Mutual (FM):

1. FM Approved: Factory Mutual Approval Guide.

G. National Fire Protection Association (NFPA):

1. 24: Installation of Private Fire Service Mains and Their Appurtenances.

H. Underwriters Laboratories (UL):

1. 246: Hydrants for Fire-Protection Service.

I. Underwriters' Laboratories of Canada (ULC)

1. S520: Hydrants.

K. American Public Works Association (APWA) Utah Chapter

1. 2017 Manual of Standard Plans and Specifications

1.03 DEFINITIONS:

- A. Appurtenances: Additional piping items as required to provide a complete piping system suitable to convey water as specified and intended. These items may or may not be specified but are necessary to complete the piping system.

1.04 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 1. Pipe materials
 2. Pipe fittings

3. Pipe couplings
 4. Pipe thrust restraint
 5. Valves
 6. Fire Hydrants
 7. Accessories including, but not limited to, nuts, bolts, and gaskets.
 8. Appurtenances
 9. NSF 61 certifications
- B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
 - C. Instructions: Provide manufacturer's installation instructions for pipe, hydrants, valves joint restraints, and meters.
 - D. Tapping Contractor qualifications and experience documentation.
 - E. Field Test Reports: Provide results for hydrostatic and bacteriological tests.
 - F. Project Record Documents: Provide actual locations of piping mains, valves, connections, thrust restraints, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.
- 1.05 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
- 1.06 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Perform Work in accordance with 2017 APWA Utah Chapter Manual of Standard Plans and Specifications as modified by Provo City 2023 Standard Drawing Details.
 - C. Valves: Manufacturer's name, UL/FM and pressure rating marked on valve body.
 - D. Materials used for fire line shall be UL listed and approved by Factory Mutual.
 - E. NSF Certification: Material used in manufacture of items specified herein shall be certified to NSF 14 and 61, as applicable. Certified items shall bear the NSF label.
- 1.07 DELIVERY STORAGE AND HANDLING
- A. Comply with the requirements specified in Section 01 66 10.

- B. Deliver and store valves in shipping containers with labeling in place.

1.08 WARRANTY:

- A. Provide standard product warranties for piping materials and as required by 2017 APWA Utah Chapter Manual of Standard Plans and Specifications as modified by Provo City 2023 Standard Drawing Details.

1.09 TAPPING CONTRACTOR QUALIFICATIONS:

- A. Tapping Contractor shall have performed successful pressure taps on ductile iron pipe (DIP) and polyvinyl chloride (PVC) water mains and shall have been engaged in tapping installation for a minimum of 3 years, with at least 5 projects in the last 3 years of similar size and type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Water Pipe (Copper):
 - 1. Mueller Streamline
 - 2. Cerro Flow Products
 - 3. Great Lakes Copper
- B. Water Pipe (HDPE C906)
 - 1. JM Eagle
 - 2. WL Plastics
 - 3. Independent Pipe Products
 - 4. Performance Pipe
- C. Water Pipe (Steel)
 - 1. See Section 40 23 19.03
- D. Water Pipe (Ductile Iron)
 - 1. See Section 40 23 19.04
- E. Gate Valves:
 - a. Mueller Co.

- b. American Flow Control
 - c. Kennedy Valve Co.
- F. Butterfly Valves:
 - 1. Av-Tek
 - 2. VAG
 - 3. American AVK
- G. Corporation Stops: Mueller H-15000, Ford F600
- H. Fire Hydrants – Provide fire hydrants manufactured by the following:
 - 1. Mueller A-423.
 - 2. American AVK 2780 Nostalgic.
 - 3. Waterous WB-67.
- I. Structures – Provide structures manufactured by the following:
 - 1. Valve Boxes: Tyler 6850, D&L M-9042.
- J. Tapping Sleeves:
 - 1. JCM Industries Model #432
 - 2. Ford Meter Box Company, Inc.
 - 3. Smith-Blair
 - 4. Romac Industries Model SST
- K. Flange Coupling Adapters:
 - 1. Dresser
 - 2. Baker
 - 3. Viking Johnson
 - 4. Romac
- 2.02 WATER PIPE:
 - A. Copper Tubing: ASTM B 88, Type K, annealed.

1. Fittings: ASME B16.18, cast copper, or ASME B16.22, wrought copper.
2. Joints: Compression connection or AWS A5.8, BCuP silver braze.
3. Only lead-free solder shall be used.
4. Working Pressure: Minimum of 100 psi (690 kPa).

2.03 SAFETY TAPE FOR BURIED PIPELINES:

- A. Safety tape shall be a minimum of 3-inch wide by 5.0 mil overall thickness, with no less than a 0.35-gauge solid aluminum foil core. It shall be Safety Blue in color per American Public Works Association (APWA) National Color Code and shall be clearly labeled with the words "CAUTION POTABLE WATER LINE BELOW" or similar wording approved by ENGINEER. Safety tape shall be MagnaTec by Empire Level Mfg Corp or approved equal.

2.04 TRACER WIRE FOR BURIED PIPELINES:

- A. All piping (including service lines) shall be installed with #14 UF-G direct bury blue tracer wire for pipeline location purposes by means of an electronic line tracer. The wires must be installed along the entire length of the pipe on the top of the pipe and be held in place with poly tape at all pipe joints and at 5 foot intervals. Sections of wire shall be spliced together using approved splice caps and waterproof seals. Twisting the wires together is not acceptable.

2.05 VALVES:

- A. Gate Valves:
 1. 150 psi working pressure. AWWA C515, Iron body, bronze trim, non-rising stem with square nut, single wedge, resilient seat, flanged x flanged ends or flanged x mechanical joint ends (as indicated on the Contract Drawings).
 2. Protective coatings per AWWA C550.
 3. UL Listed/FM Approved.
 4. Provide one operating wrench of length to operate deepest valve.

2.06 DOUBLE OFFSET BUTTERFLY VALVES – LIQUID SERVICE (AWWA):

- A. Double Offset Butterfly valves shall have a double offset disc design whereby the centerline of the disc is horizontally and vertically offset from the body seat and where the elastomeric seat release compression only after a few degrees of the opening to reduce torque and seat wear, also known as a double eccentric type. Valves shall be designed, manufacturer and tested in accordance with AWWA C504, except as modified herein.

- B. Double Offset Butterfly valves shall be rated for working pressures of no less than 250 psi and shall provide zero leakage at full rated pressure on both sides of the disc.
- C. Provide valves that conform to NSF Standard 61 and NSF 372.
- D. Disc body shall conform to ASTM A536 65-45-12 or 60-40-18 for non-submerged valves and shall be Type 316 stainless-steel for submerged valves and shall be pinned used 2205 Duplex stainless steel pin. Disc seat shall be elastomeric and shall be secured to the disc with Type 316 stainless steel hardware. Disc seat shall be EPDM unless manufacturer recommends alternative which demonstrates better resistance to abrasion. The disc shall be a flow through design to reduce head loss.
- E. Body seat shall be 316L stainless steel and shall be applied through a high alloy weld double overlay process with a minimum thickness of 5 mm.
- F. Valve Stems shall be Type 431 stain steel for Class 150B and 17-4 PH stainless steel for Class 250 valves. Valve stems shall be dry stem design with O-rings.
- G. The valves shall have a heavy-duty ductile iron body conforming to ASTM A 536 65-45-12. Maximum flow velocity shall be less than 16 fps for cold water service.
- H. Valve End Connections:
 - 1. Exposed or submerged service: Flanged fully faced and drilled per ANSI B16.1 Class 150B
 - 2. Buried service: Mechanical joint.
- I. Valve Seats:
 - 1. Potable Water Service: EPDM.
 - 2. The rubber seat shall be clamped or mechanically secured in the valve disc with a continuous Type 316 stainless steel ring with Type 316 stainless steel fasteners. The rubber seat shall be a continuous uninterrupted sealing surface.
 - 3. Resilient seats shall be field replaceable without the use of special tools or epoxy.
- J. The resilient seat mating surface shall be a continuous uninterrupted Type 316 stainless steel ring mounted in the valve body.
- K. Plated or sprayed on mating surface material not acceptable.
- L. Bearings:
 - 1. The bearings shall be corrosion resistant, self-lubricating sleeve type, made from bronze or PTFE impregnated copper with steel backing.
 - 2. Thrust bearings shall be provided and shall be adjustable.

- M. The valve disc shall be rigidly connected to the stem by two pins for each shaft plus one backup safety key. The pins shall be protected for water and corrosion by O-ring seals.
- N. All bolting and hardware shall be stainless steel AISI grade 316.
- O. Shaft: Type 316 or 2205 duplex stainless steel. Either one piece extending completely through disc or stub shafts inserted into valve disc stubs.
- P. Shaft seal of the split-V type or O-ring type. Seal replaceable without disassembly of valve.
- Q. The valve shall have a fusion bonded epoxy protective coating inside and outside with a minimum DFT of no less than 14 mils. Coating shall meet AWWA C550 and shall be non-toxic and impart no taste to water. There shall be no exposed, uncoated iron in the interior or exterior of the valve.
- R. Provide gear operator with operating nut and valve box. Gear operator to be totally enclosed with gasketed Type 316 stainless steel covers with Type 316 stainless steel fasteners for access to valve packing.

2.07 MANUAL OPERATORS:

A. General:

1. Operator force not to exceed 40 lbf under any operating condition, including initial breakaway. Gear reduction operator when force exceeds 40 lbf.
2. Operator to be self-locking type or be equipped with self-locking device.
3. Provide position indicator on quarter-turn valves.
4. Worm and gear operators to be one-piece design worm-gears of gear bronze material. Worm hardened alloy steel with thread ground and polished. Traveling nut type operators to have threaded steel reach rods with internally threaded bronze or ductile iron nut.

B. Buried Operator:

1. Buried service operators shall have a 2-inch AWWA operating nut. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
2. Design buried service operators for quarter-turn valves to withstand 450 lbf-ft of input torque at the FULLY OPEN or FULLY CLOSED positions, grease packed and gasketed to withstand a submersion in water to 10 psi.
3. Buried valves shall have extension stems, bonnets, and valve boxes.

C. Submerged Operator

1. Submerged service operators shall be design for continuously submerged service and be NSF 61 certified.
2. Submerged service operators shall have a 2-inch AWWA operating nut. Enclose moving parts of valve and operator in housing to prevent contact with the water.
3. Design submerged service operators for quarter-turn valves to withstand 450 lbf-ft of input torque at the FULLY OPEN or FULLY CLOSED positions, food grade grease packed and gasketed to withstand a submersion in water to 12 psi.
4. Submerged valves shall have Type 316 stainless-steel extension stems and stem guides from the valve operator to the Clearwell roof deck as shown on the Contract Drawings, bonnets, and sealed Type 316 stainless steel valve (floor) boxes by Trumbull Manufacturing or approved equal.

2.08 VALVE BOXES:

- A. General: Provide cast-iron valve boxes, rated for vehicular traffic.
- B. Cast-Iron Boxes: Extension type with screw-type adjustment, flared base and 3/16-inch minimum thickness of metal.
- C. Cast the word "WATER" in cover. Adapt box length, without full extension, to depth of cover required over pipe at valve location.

2.09 FIRE HYDRANTS:

- A. AWWA C502, UL 246, dry barrel type compression hydrant with O-ring seals; counterclockwise rotation to open. Protective interior coating per AWWA C550. Hydrants to be factory painted red.
- B. Equip with a 4-1/2 inch valve opening, 6-inch mechanical joint shoe, two 2-1/2 inch hose nozzles, and one 4 inch nozzle breakaway flange and stem coupling.
- C. Provide threads on nozzles in conformance with National Standard firehose coupling screw-thread dimensions. Nozzles shall be replaceable.
- D. Working Pressure: 350 psi.
- E. Provide 1 repair kit.
- F. UL Listed/FM Approved.

2.10 BEDDING AND COVER MATERIALS:

- A. As specified in Section 31 23 33.

2.11 DISMANTLING JOINTS:

- A. Provide dismantling joint were shown on the Contract Drawings. CONTRACTOR will not be allowed to substitute any other type of dismantling joint unless approved by ENGINEER. The dismantling joint shall be rated as indicated on the Contract Drawings.
- B. Dismantling joint bodies shall be fabricated from steel, ASTM A512 or A 513 or Ductile Iron ASTM A536, without pipe stop. The body shall not be less than 1/4-inch thick or at least the same wall thickness as the pipe to which the dismantling joint is connected. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe. The follower ring shall be fabricated from steel, ASTM A576 or A36.
- C. For dismantling joints installed in piping systems rated for positive pressure, the joint shall be restrained with harness bolts or tie rods. Other means of restraining the joint such as set screws will not be accepted. Harnesses shall be designed in accordance with AWWA Manual 11, or as indicated. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed.
- D. Gaskets shall be composed of a rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions.
- E. Dismantling joint shall be Model 975 by Smith-Blair, Model 309 by JCM, Model DJ400 by Romac, or approved equal.

2.12 RESTRAINED FLANGE COUPLING ADAPTERS:

- A. Materials:
 - 1. Flanged Spool: AWWA Class D steel ring flange compatible with ANSI class 125 and 150 bolt circles, ASTM A36 steel or ASTM A283C steel.
 - 2. End Ring and Body: ASTM A36 steel or ASTM A283C steel
 - 3. Gaskets: SBR suitable for wastewater service
 - 4. Bolts and Nuts: HSLA carbon steel
 - 5. Restrained gland and wedges: ASTM A536 grade 65-45-12
- B. Assembly Tolerance: 3 inches
- C. Coating: Fusion bonded epoxy
- D. Pressure Rating: 150 psi working pressure
- E. NSF 61 certified

F. Manufacturers

1. Dresser
2. Baker
3. Viking Johnson
4. Romac
5. Smith Blair

2.13 TAPPING SLEEVES:

- A. Stainless steel split-sleeve type with flanged outlet, bolts, follower rings and gaskets on each end of sleeve suitable for maximum working pressure of 150 psi. Bolts shall have square heads and hexagonal nuts. Longitudinal gaskets shall be as recommended by manufacturer of sleeve.
- B. Flange shall be ductile iron meeting ASTM A536 grade 65-45-12.
- C. Sidebars and lugs: Type 304 stainless steel, heavy gauge.
- D. Test Ports and Test Plug: Type 304 stainless steel, Test port shall be 3/4-inch FNPT. Plug shall be coated to prevent galling.
- E. Bolts and nuts shall be Type 304 stainless steel. Nuts shall be coated to prevent galling.
- F. Gasket shall SBR and shall provide seal around full circumference of pipe. Reinforced ring at outlet provides hydrodynamic seal.
- G. Tapping Valves: Provide tapping valves that conform to gate valves, specified herein. Provide tapping valves suitable for installation with tapping sleeves and pipe used, designed for minimum water working pressure of 150 psi, and have clear waterway equal to full nominal diameter of valve.

2.14 COLD-APPLIED WAX TAPE COATING

- A. All buried appurtenances such as flanges, bolts, nuts, valves, actuators, restrained harnesses, couplings, and all metallic appurtenances shall be wax tape coated as specified herein.
- B. Primer: Primer shall be a blend of petrolatums, plasticizers, and corrosion inhibitors having a paste-like consistency. The primer shall have the following properties:
 1. Pour Point 100°F to 110°F
 2. Flash Point 350°F

3. Coverage 1 gallon/100 square feet
 4. Manufacturer Trenton Wax Tape Primer, Denso Paste Primer, or approved equal.
- C. Mastic: Mastic shall be a moldable filled petroleum or petrolatum wax. Mastic shall be Treton Fill-pro PM-GP, Densyl Mastic, or approved equal.
- D. Wax Tape: Wax tape shall consist of a synthetic-fiber felt, saturated with a blend of microcrystalline wax, petrolatums, plasticizers, and corrosion inhibitors, forming a tape coating that is easily formable over irregular surfaces. The tape shall have the following properties:
1. Saturant Pour Point 115°F to 120°F
 2. Thickness 50 to 70 mils
 3. Tape Width 6 inches
 4. Dielectric Strength 100 volts/mil
 5. Manufacturer Trenton No. 1 Wax Tape, Denso "Densyl Tape", or approved equal.
- E. Outer Wrap: Outer wrap shall be a polyvinylidene chloride plastic with three 50-gaugeplies wound together as a single sheet. The wrap shall have the following properties:
1. Thickness 1.5 mils
 2. Tape Width 6 inches
 3. Manufacturer Trenton Poly-Ply, Denso Tape PVC Self-Adhesive, or approved equal.

2.15 MECHANICAL SEALS

- A. Manufacturers:
1. Garlock/Link-Seal
 2. APS/Innerlynx
- B. Materials:
1. Seal element: EPDM
 2. Pressure Plate: Composite
 3. Nuts and Bolts: Stainless Steel

2.16 BOLTS AND NUTS

- A. All flanges, both buried and exposed, shall have stainless steel nuts and bolts as follows: Bolts shall have ASME B1.1, Class 2A threads, and be manufactured of ASTM A193, Grade B8M and conform to ASME B18.2.1, and nuts shall have Class 2A fit, square or hex heavy dimensions in accordance with ASME B18.2.2, and be manufactured of ASTM A194, Grade 8B heavy hex.

2.17 INSULATING FLANGE KIT

- A. Insulating flange kits shall be dielectric type with a rating equal to or higher than that of the joint and pipeline. All materials shall be resistant for the intended exposure, operating, temperatures and products in the pipeline.
- B. Manufacturers:
 - 1. Linebacker by GPT
 - 2. Flange Isolating Gasket Kit by APS
- C. Gasket materials shall be resistant to intended chemical exposure, operating temperatures, and pressure in the pipeline. Gaskets shall be full face Type E with O-ring seal.
- D. Insulating washers and full-length sleeves shall be fiberglass reinforced epoxy (NEMA G-10 grade). Insulating washers shall have a dielectric strength of 400 to 500-volts/mil. Insulating washers shall be installed with metallic backing washers to prevent damage to the epoxy-glasswasher during bolting. The metallic washers shall be constructed of the same material as the bolts. Contactor may use molded sleeve washers as an alternate to separate washers and sleeves, as long as the material of construction has equivalent properties to those above.

2.18 SHOP TESTING:

- A. Test pipes, valves, hydrants, and applicable accessories per manufacturer requirements, and as required by referenced Standards.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify existing conditions.
- B. Verify building service connections and municipal utility water main sizes, locations and inverts are as indicated.

3.02 PREPARATION:

- A. Ream pipe and tube ends and remove burrs.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare pipe connections to equipment with flanges or unions.
- D. Excavate pipe trench in accordance with Section 31 23 23 for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.

3.03 WATER PIPE INSTALLATION:

- A. Maintain separation of water main from sewer as follows:

1. Parallel Installation

- a. Under normal conditions water mains shall be laid at least 10 feet horizontally from a sewer or sewer manhole. The distance shall be measured edge-to-edge.
- b. Under unusual conditions when local conditions prevent a horizontal separation of 10 feet the water main may be laid closer to a sewer or sewer manhole provided that:
 - (1) The bottom (invert) of the water main shall be at least 18 inches above the top (crown) of the sewer,
 - (2) Where this vertical separation cannot be obtained, the sewer shall be constructed of AWWA approved water pipe, pressure tested in place without leakage prior to backfilling, and
 - (3) The sewer manhole shall be of watertight construction and tested in place.

2. Crossing

- a. Under normal conditions water lines crossing sewers shall be laid to provide a separation of at least 18 inches between the bottom of the water line and the top of the sewer whenever possible.
- b. Under unusual conditions when local conditions prevent a vertical separation described, the following construction shall be used:
 - (1) Sewers passing over or under water mains shall be constructed of AWWA approved water pipe, pressure tested in place without leakage prior to backfilling,

- (2) Water lines passing under sewers shall, in addition, be protected by providing:
 - (a) A vertical separation of at least 18 inches between the bottom of the sewer and the top of the water line,
 - (b) Adequate structural support for the sewers to prevent excessive deflection of the joints and the settling on and breaking of the waterline; and
 - (c) That the length of the water line be centered at the point of the crossing so that joints shall equidistant and as far as possible from the sewer.
 - (3) No water pipes shall pass through or come in contact with any part of a sewer manhole.
 - B. Install pipes and structures to within tolerance of 1/2-inch of indicated elevations.
 - C. Install fire service piping according to NFPA 24.
 - D. Install joint restraint per manufacturer's instructions. Submit instructions to Engineer.
 - E. Establish elevations of buried piping to ensure not less than 52 inches of cover underneath traffic areas.
 - F. Install trace wire continuous over top of pipe, coordinate with Section 31 23 33. Extend wire into valve boxes and adjacent to hydrants for connection to location equipment.
 - G. Backfill trench in accordance with Section 31 23 33
- 3.04 VALVES AND HYDRANTS INSTALLATION:
- A. Set valves on solid bearing.
 - B. Center and plumb valve box over valve. Set box cover flush with finished grade.
 - C. Set hydrants plumb and locate pumper nozzle perpendicular to roadway.
 - D. Provide at least one (1) cubic yard of drain rock around drain hole at base of hydrant spool. Wrap geotextile around drain rock and tape geotextile to hydrant spool to prevent sitting of sewer rock. Apply non-oxide grease to all buried metal surface. Wrap with polyethylene sheet and tape wrap. Provide 12 inches sand bedding around all piping. Notify fire department at (801) 852-6300 as soon as hydrant is placed in service.
 - E. Perform tapping of water mains by qualified personnel. Maintain a minimum of 36 inches between taps, and a minimum of 24 inches clear from pipe joints. Install tapping saddles in accordance with manufacturers requirements. Keep trench open at tap until

branch line has been placed in service so tap can be inspected for leakage. Following disinfection procedures per Section 33 13 00.

- F. Install valves according to applicable AWWA Standards and NFPA 24.

3.05 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM:

- A. Refer to Section 33 13 00.

3.06 SERVICE CONNECTIONS:

- A. Provide water service including service saddle, corporation stop, and polyethylene pipe.

3.07 REPAIR/RESTORATION:

- A. Repair any existing utilities, structures, or features damaged during installation of water utilities to Owner's satisfaction, and at no cost to Owner.

3.08 FIELD TESTING:

- A. Perform field-testing under provisions of Section 01 45 23 and according to NFPA 24.
- B. Hydrostatically test newly laid pipeline and valved section thereof in accordance with AWWA C600 and NFPA 24.
- C. Bacteriological testing shall be in accordance with Section 33 13 00.

3.09 FIELD PAINTING/COATINGS:

- A. Repair any shop painting/coatings damaged during storage or installation to Owner's satisfaction.

3.10 COLD-APPLIED WAX TAPE COATING APPLICATION

- A. Surfaces shall be clean and free of all dirt, grease, water, and other foreign material prior to the application of the primer and wax tape.
- B. Apply primer by hand or brush to all surfaces of the pipefitting or valve. Work the primer into all crevices and completely cover all exposed metal surfaces.
- C. For larger voids or irregular shaped surfaces fill spaces with a moldable mastic.
- D. Apply the wax tape immediately after the primer application. Work the tape into the crevices around fittings. Wrap the wax tape spirally around the pipe and across the fitting. Use a minimum overlap of 55 percent of the tape width.
- E. Work the tape into the crevices and contours of irregularly shaped surfaces and smooth out so that there is a continuous protective layer with no voids or spaces under the tape.

- F. Overwrap the completed wax tape installation with the plastic wrapping material. Wrap spirally around the pipe and across the fitting. Use a minimum overlap of 55 percent of the tape width and apply two layers or applications of overwrap. Secure plastic wrapper to pipe with adhesive tape.

3.11 ADJUSTING:

- A. Coordinate with Engineer for any field adjustments. The Engineer and Owner reserves the right to reject any field adjustments.

3.12 PROTECTION:

- A. Protect installed water utilities from damage throughout storage, installation, testing, and final approval.

3.13 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 33 13 00

DISINFECTING OF WATER UTILITY DISTRIBUTION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide disinfecting of water utility distribution systems, water treatment plant, and Clearwell as indicated and in compliance with Contract Documents.
- B. Section Includes:
 - 1. Disinfection of water pipelines in accordance with AWWA C651, water storage facility in accordance with AWWA C652, and water treatment plants in accordance with AWWA C653; except as modified below.

1.02 REFERENCES:

- A. American Water Works Association (AWWA):
 - 1. C651: Disinfecting Water Mains.
 - 2. C652: Disinfection of Water-Storage Facilities.
 - 3. C653: Disinfection of Water Treatment Plants.

1.03 SEQUENCING:

- A. Basic procedure for disinfecting water mains:
 - 1. Inspecting materials to be used to ensure their integrity.
 - 2. Preventing contaminating materials from entering the water main during storage, construction, or repair and noting potential contamination at the construction site.
 - 3. Removing, by flushing or other means, those materials that may have entered the water main.
 - 4. Chlorinating any residual contamination that may remain and flushing the chlorinated water from the main.
 - 5. Protecting the existing distribution system from backflow caused by hydrostatic pressure test and disinfection procedures.
 - 6. Documenting that an adequate level of chlorine contacted each pipe to provide disinfection.

7. Determining the bacteriological quality by laboratory test after disinfection.
8. Final connection of the accepted new water main to the active distribution system.

1.04 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 1. Supervisor qualifications
 2. Equipment list

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Regulatory Requirements:
 1. Disinfection work shall be acceptable to the Owner and the Utah Division of Drinking Water (DDW). If requirements of this section are in conflict with requirements of regulatory agencies, the most strict requirement shall govern.
- C. Source Quality Assurance:
 1. Perform Work in connection with disinfection under direction of experienced supervisor.
 2. Use equipment in proper working condition and adequate for specified Work.
- D. Prior to starting disinfection work, furnish detailed outline of proposed sequence of operation, manner of filling and flushing units, source, and quality of water to be used, and disposal of wasted water.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.07 PROJECT CONDITIONS:

- A. Discharge of chlorinated water into watercourses or surface waters is regulated by the National Pollutant Discharge Elimination System (NPDES). Disposal of the chlorinated disinfection water and the flushing water is the Contractor's responsibility. Dechlorinate the disinfection water such that the chlorine residual does not exceed 0.019 ppm prior to discharging.
- B. Schedule the rate of flow and locations of discharges in advance to permit review and coordination with Owner and the DDW. The allowable location of discharge is the Mill Race Canal which discharges into the Provo River.

PART 2 - PRODUCTS

2.01 OWNER-SUPPLIED PRODUCTS:

- A. The Owner will provide potable water for the first disinfection effort. Submit request for use of water from waterlines of Owner 48 hours in advance. If bacteriological testing shows that the first disinfection effort was not successful, the Contractor will be charged at the Owner's current rates, the cost of additional water for subsequent disinfection efforts.

2.02 MATERIALS:

- A. Water: Use potable water for cleaning and disinfection.
- B. Chlorine: Provide in accordance with AWWA C652.
 - 1. Liquid Chlorine: Inject with a solution feed chlorinator and a water booster pump. Follow the instructions of the chlorinator manufacturer.
 - 2. Calcium Hypochlorite (Dry): Dissolve in water to a known concentration in a drum and pump into the pipeline at a metered rate. Tablet form calcium hypochlorite may be used only for water mains up to 12 inches in diameter and less than 2,500 feet in length.
 - 3. Sodium Hypochlorite (Solution): Further dilute in water to desired concentration and pump into the pipeline at a metered rate.

2.03 EQUIPMENT:

- A. Submit list of equipment used for disinfecting work. Makeup tanks and pumps proposed shall not have previously been used in conjunction with sanitary sewer or storm drain work.

2.04 ACCESSORIES:

- A. Chlorine Residual Test Kit: For measuring chlorine concentration, supply and use a medium range, drop count, DPD drop dilution method kit per AWWA C651, Appendix A.1. Maintain kits in good working order available for immediate test of residuals at point of sampling.

PART 3 - EXECUTION

3.01 PREPARATION:

- A. Isolate new work being disinfected from system to avoid possibility of contaminating materials entering distribution system.

B. Water Storage Facilities:

1. Remove debris and material not part of structural or operating facilities of tank.
2. Clean using high pressure water jet or other equally effective means to remove dirt and foreign material.
3. Cleaning shall:
 - a. Remove deposits of foreign nature.
 - b. Remove growths.
 - c. Broom walls, floor, and ceiling.
 - d. Avoid damage to structure.
 - e. Avoid contamination by workers and equipment.
4. Remove water, dirt, and foreign material and dispose.
5. Water used in cleaning the water storage facilities shall be wasted before adding chlorinating agent to facilities.

C. Method of disinfection for water containment devices and piping systems shall conform to AWWA C651.

D. Contractor shall be responsible for damages arising from direct contact of granular calcium hypochlorite with solvent welding materials used to join PVC pipe.

3.02 CHLORINE PREPARATION:

A. Liquid Chlorine:

1. Apply chlorine gas-water solution by means of solution feed chlorinating device or, if accepted by Engineer, dry gas may be fed directly through proper devices for regulating rate of flow and providing effective diffusion of gas into water within unit being treated.
2. Provide chlorinating devices for feeding solutions of chlorine gas that prevent backflow of water into chlorine cylinder.

B. Calcium Hypochlorite:

1. Prepare granular calcium hypochlorite as water mixture before introduction into unit. Make dry powder into paste and thin to approximately 1 percent chlorine solution.

2. To prepare chlorine solution, add 1 lb of calcium hypochlorite (65 to 70 percent available chlorine) to 8-1/3 gallons of water.

3.03 PIPELINE PREPARATION:

- A. After pressure and leakage tests complete, flush units thoroughly to remove foreign material.
- B. Release entrapped air at high points and fill units with disinfecting agent and water to allow disinfecting agent to come in contact with interior surfaces.
- C. If complete venting cannot be accomplished through available outlets, provide necessary corporation cocks and vent piping.

3.04 APPLICATION OF DISINFECTANT:

A. Point of Application:

1. Apply chlorinating agent at supply end of unit being disinfected.
2. For pipes, apply disinfectant through corporation cock installed in top of pipe.
3. Place tablets in accordance with AWWA C651.

B. Rate of Application:

1. Introduce water at controlled rate in order to regulate chlorine dosage.
2. Proportion rate of chlorine mixture flow to rate of water entering unit so chlorine dose applied produces at least 25 mg/L chlorine residual after period of 24 hours.
3. Method of determining rate of flow of water into unit being disinfected shall be accepted by Engineer.

C. Isolating Systems:

1. Keep chlorine gas-water disinfecting solution and contaminated water from flowing into units previously chlorinated and flushed.

D. Quality:

1. Retain chlorinated water in unit long enough to destroy non-spore forming bacteria.
2. Minimum retention period shall be 24 hours with chlorine residual at end of this period of not less than 25 mg/L (ppm).

E. Disinfecting Valves:

1. Operate valves and appurtenances while line or unit is being disinfected to ensure surfaces of valves are disinfected.

F. Swabbing:

1. Flush and swab pipe, fittings or valves that must be placed in service immediately with 5 percent solution of calcium hypochlorite immediately prior to assembly.
2. Secure acceptance from Engineer before using this method of disinfection.

G. Valve Operation: Performed by Owner.

3.05 DISINFECTING METHODS:

A. Continuous Feed Method:

1. Introduce potable water into the pipeline at a constant measured rate. Feed the chlorine solution into the same water at a measured rate. Proportion the two rates so that the chlorine concentration in the pipeline is maintained at a minimum concentration of 25 mg/L. Check the concentration at points downstream during the filling to ascertain that sufficient chlorine is being added.

B. Slug Method:

1. Introduce the water in the pipeline at a constant measured rate. At the start of the test section, feed the chlorine solution into the pipeline at a measured rate so that the chlorine concentration created in the pipeline is 300 mg/L. Feed the chlorine for a sufficient period to develop a solid column or "slug" of chlorinated water that will, as it passes along the line, expose all interior surfaces to a concentration of at least 300 mg/L for at least three hours.

C. Disinfection of Valves, Blind Flanges, and Appurtenances:

1. During the period that the chlorine solution or slug is in the section of pipeline, open and close valves to obtain a chlorine residual at hydrants and other pipeline appurtenances. Swab exposed faces of valves and blind flanges prior to bolting flanges in place with a 1 percent sodium hypochlorite solution.

D. Disinfection of Connections to Existing Pipelines

1. Disinfect isolation valves, pipe, and appurtenances in accordance with AWWA C651, Section 4.7. Flush with potable water until discolored water, mud, and debris are eliminated. Swab interior of pipe and fittings with a 1 percent sodium hypochlorite solution. After disinfection, flush with potable water again until water is free of chlorine odor.

E. Disinfection of Tapping Sleeves and Line Stopping:

1. Flush exterior of pipe with potable water after removal of existing coating. Swab exterior of pipe with a 1 percent sodium hypochlorite solution. Disinfect per AWWA C651, Section 4.8. After completion of tapping and line stopping, swab interior of pipe, valves, and faces of flanges to be connected to bypass piping with a 1 percent sodium hypochlorite solution.

F. Confirmation of Residual:

1. After the chlorine solution applied by the continuous feed method has been retained in the pipeline for 24 hours, confirm that a chlorine residual of **25 mg/L** minimum exists along the pipeline by sampling at air valves and other points of access.
2. With the slug method, confirm by sampling as the slug passes each access point and as it leaves the pipeline that the chlorine concentration in the slug is at least 50 mg/L.

3.06 FINAL FLUSHING AND TEST:

- A. Following chlorination, flush unit or system until replacement water in system is proven to be comparable in quality to water which will enter unit or system.
- B. Above acceptable condition of water delivered by each unit or system shall continue for at least 2 days, as demonstrated by laboratory examination of samples. Laboratory tests shall show chlorine residual, after final flushing, of less than 0.3 mg/L (ppm).
- C. Repetition of Flushing and Testing:
 1. If initial treatment results in unsatisfactory bacterial test, repeat disinfection until satisfactory results obtained.
- D. Prevent entry of contaminated water into previously disinfected units or systems.

3.07 DISINFECTING CLEARWELLS:

- A. Contractor shall disinfect the Clearwells in accordance with the latest revision of AWWA C652 "DISINFECTION OF WATER-STORAGE FACILITIES". Only AWWA approved methods, i.e., chlorination of the full storage, or spraying or painting of surfaces, will be allowed.
- B. Contractor shall submit to Engineer a proposed plan for disinfecting the Clearwells. The plan shall include a method of disposing of any high concentrations of chlorine solution.
- C. After the chlorination procedure is completed, and before the Clearwells are placed in service, water from the full facility shall be sampled and tested by OWNER for coliform

organisms in accordance with the latest edition of "Standard Method for the Examination of Water and Wastewater".

- D. Test for Odor. The water in the full facility will also be tested to assure that no offensive odor exists due to chlorine reactions or excess chlorine residual.
- E. Results of Testing. If the test for coliform organism is negative, then the Clearwells may be placed in service after obtaining and Operating Permit from the Utah Division of Drinking Water. If the test shows the presence of coliform bacteria, then the situation shall be evaluated by a qualified Engineer. In any event, repeat samples shall be taken until two consecutive samples are negative, or the storage facility shall again be subjected to disinfection at no additional cost to OWNER.
- F. Cost of water and chlorine for re-chlorination of the Clearwells if first attempt does not test safely shall be Contractor's responsibility.

3.08 DISINFECTING WATER TREATMENT PLANTS:

A. Disinfection of tanks and storage facilities

- 1. Tanks and similar receptacles shall be disinfected using one of the methods described in AWWA C652, including application methods, chlorine solution strengths, retention times, disposal of highly chlorinated water, and bacteriological sampling and testing.
- 2. Disinfect the following tanks:
 - a. UF Filtrate Backwash Storage Tank
 - b. CIP tanks
 - c. Backwash recycle tanks

B. Disinfection of UF filters

- 1. After all work is completed, disinfect the UF system by chlorination.
- 2. Disinfection of the UF system can be accomplished by conducting a maintenance clean procedure with a chlorine residual of no less than 25 mg/L.
- 3. Allow chlorinated water to soak in the filters for up to 12 hours, or as recommended by the UF system manufacturer to avoid oxidation damage to the system.
- 4. If the total coliform test is positive after disinfection, repeat until acceptable results are obtained.

C. Disinfection of piping

1. Perform flushing and disinfection of piping as specified previously in this section.
2. Flushing requirements
 - a. Flush new mains, including fire service mains and lead-in connections to fire system risers, thoroughly before connection is made to system piping in order to remove foreign materials that might have entered the main during the course of the installation.
 - b. Flushing shall be of sufficient magnitude and duration to flush all foreign material out of the lines, valves, and hydrants. The flushing velocity shall be a minimum of 2.5 feet per second (ft/s) for non-fire protection lines. Where the main supplies a fire protection system the velocity shall meet the NFPA 24 requirement of 10 ft/s.
 - c. All valves and hydrants shall be fully opened and closed under water pressure to ensure proper operations during flushing and to dislodge foreign material. All valves on fire protection lines (except curb box valves) shall be sealed with a plastic seal in the normal position (opened or closed) at the conclusion of testing. During flushing operations, all valves or connections to existing systems shall be closed and backflow preventers or other approved equipment installed at the source to prevent contamination of existing systems.
3. Disinfection requirements
 - a. Disinfect all piping on the project except the following:
 - (1) Storm sewers, sanitary sewers, and roof drainage piping.
 - (2) Other site drainage piping including overflows.
 - (3) Sanitary vents and sump pump discharge piping.
 - (4) Chlorine gas and sodium hypochlorite piping.
 - (5) Piping associated with the chlorine gas scrubber
 - (6) Tank vent piping
 - (7) Ozone off-gas air piping.
 - b. Piping associated with the ozone system shall be disinfected prior to conducting the special cleaning requirements specified in Section 46 31 53.

3.09 BACTERIOLOGIC TESTS:

- A. Owner will collect two sets of samples per AWWA C651, Section 5.1, deliver to a certified laboratory within six hours of obtaining the samples, and obtain a bacteriologic

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quality test to demonstrate the absence of coliform organisms in each separate section of the pipeline and in each structure after chlorination and refilling. Collect at least one set of samples from every 1,200 feet of the new water line and line stopping insertion point, plus one set from the end of the line and at least one set from each branch. At each connection to an existing pipeline, take two additional samples.

- B. Repetition of Procedure: If the initial chlorination fails to produce required residuals and bacteriologic tests, repeat the chlorination and retesting until satisfactory results are obtained.
- C. Test Facility Removal: After satisfactory disinfection, disinfect and replace air valves, restore the pipe coating, and complete the pipeline where temporary disinfection or test facilities were installed.

3.10 FIELD QUALITY CONTROL:

- A. Owner will obtain samples for and submit to laboratory for analysis before the WTP facilities are placed in service.
- B. If safe samples not obtained using above procedure, Contractor shall add additional chlorine in amounts necessary to obtain safe samples.

3.11 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 33 30 00

SANITARY SEWERAGE UTILITIES

PART 1 - GENERAL

1.01 SUMMARY:

A. Excluded from this section are:

1. Yard process piping between structures for water treatment plants. Refer to Division 46 for yard process piping.
2. Water utilities within 5 feet from buildings. Refer to Division 22 for plumbing piping.
3. Precast concrete manholes, rings and covers and manhole steps. Refer to Section 33 95 15.

1.02 DESCRIPTION:

- A. Provide gravity sanitary sewers beyond 5 feet from buildings to municipal sewers or other discharge system as indicated and in compliance with Contract Documents.
- B. Section includes gravity sanitary sewers.

1.03 REFERENCES:

A. ASTM International (ASTM):

1. C14: Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
2. C76: Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
3. C443: Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
4. C478: Precast Reinforced Concrete Manhole Sections
5. C564: Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
6. C923: Resilient Connectors Between Reinforced Concrete Manhole Structures
7. C924: Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method; American Society For Testing And Materials

8. D638: Standard Test Method for Tensile Properties of Plastics
 9. D648: Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
 10. D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 11. D1785: Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
 12. D2241: Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
 13. D2321: Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
 14. D2583: Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
 15. D2729: Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
 16. D3034: Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
 17. D3139: Standard Specification for Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals
 18. D3212: Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
 19. F477: Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- B. American Water Works Association (AWWA):
1. C901: Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13 mm) Through 3 In. (76 mm), for Water Service
- C. Occupational Safety and Health Administration (OSHA) Standards and Regulations:
1. 29 CFR 1926, Subpart P: Safety and Health Regulations for Construction, Excavations
- D. UNI-BELL (UNI):
1. B3: Recommended Practice for Installation of Polyvinyl Chloride (PVC) Pressure Pipe (Nominal Diameters 4-36 Inch (100-900 mm))
 2. B6: Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe; UNI-Bell PVC Pipe Association

1.04 DEFINITIONS:

- A. Appurtenances: Additional piping items to provide a complete piping system suitable to convey wastewater as specified and intended. These items may or may not be specified but are necessary to complete the piping system.
- B. Standard Specifications: “Manual of Standard Plans and Specification – APWA Utah Chapter and Specifications as modified by Provo City 2023 Standard Drawing Details.

1.05 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 - 1. Pipe materials
 - 2. Pipe fittings
 - 3. Pipe couplings
 - 4. Accessories including, but not limited to, nuts, bolts, and gaskets.
 - 5. Appurtenances
- B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- C. Instructions: Provide manufacturer's installation instructions for pipe, valves, appurtenances, and manholes.
- D. Field Test Reports: Provide results for all testing performed as indicated in Subparagraph – Field Testing.
- E. Project Record Documents: Provide marked-up set of drawings showing actual locations of piping, valves, connections, thrust restraints, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Perform Work in accordance with the “Manual of Standard Plans and Specification – APWA Utah Chapter and Specifications as modified by Provo City 2023 Standard Drawing Details.

1.07 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.08 WARRANTY:

- A. Comply with the requirements specified in Section 01 78 36.
- B. Provide standard product warranties for piping materials and as required by 2017 APWA Utah Chapter Manual of Standard Plans and Specifications as modified by Provo City 2023 Standard Drawing Details.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Reinforced Concrete Pipe:
 - 1. Geneva Pipe and Precast
 - 2. Oldcastle Infrastructure
- B. Plastic Pipe (PVC):
 - 1. JM Eagle
 - 2. Vinyltech
 - 3. Diamond Plastics Corporation

2.02 GRAVITY SANITARY SEWER PIPE:

- A. Reinforced Concrete Pipe:
 - 1. Pipe: ASTM C76, minimum Class IV unless noted otherwise; nominal inside diameter as indicated.
 - 2. End Joints: Bell and spigot for pipes 12-inch diameter through 48-inch diameter. Tongue and groove for pipes 60-inch diameter and larger.
 - 3. Joint Device:
 - a. Watertight: ASTM C443, rubber compression gasket.
- B. Polyvinyl Chloride (PVC) Pipe:
 - 1. Pipe (4-inch through 15-inch diameter): ASTM D3034, Type PSM PVC material; minimum SDR35, nominal inside diameter as indicated.
 - 2. Pipe (18-inch through 48-inch diameter): ASTM F679, Type PSM PVC material; minimum pipe stiffness 46 psi, nominal inside diameter as indicated.

- 3. End Joints: Bell and spigot per ASTM D3212.
- 4. Joint Device: Gasket Flexible elastomeric locked-in gasket per ASTM F477.
- 2.03 PRECAST CONCRETE MANHOLES:
 - A. Precast concrete manholes shall be in accordance with Section 33 95 15.
 - B. Manhole steps shall be in accordance with Section 33 95 15.
- 2.04 MANHOLE FRAME AND COVERS:
 - A. Frame and Cover: In accordance with section 33 95 15. Cover provided with embossed lettering saying "SANITARY SEWER" cast into cover.
- 2.05 BEDDING AND COVER MATERIALS:
 - A. As specified in Section 31 23 33.
- 2.06 ACCESSORIES:
 - A. Flexible Couplings: Sleeve type elastomeric polyvinyl chloride held firmly to pipe ends by screw-tightened bands. Bands and screws Type 304 stainless steel.
- 2.07 APPURTENANCES:
 - A. Provide all necessary appurtenances for a full and complete piping system suitable for operation, and in conformance with Project Documents.
- 2.08 SHOP PAINTING/COATINGS:
 - A. Unless otherwise specified or indicated, provide standard manufacturer paint and coatings for all piping to prevent corrosion for the life of the component.
- 2.09 SHOP TESTING:
 - A. Test all pipes per manufacturer requirements, and as required by pertinent Standards.
 - B. Provide notice to the Engineer and Owner in advance of the proposed test and requirements for the test including measurements to be taken, submittal requirements, etc.

PART 3 - EXECUTION

- 3.01 EXAMINATION:
 - A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated for sanitary sewer pipe. Verify excavation for manholes to proper depth and proper placement of bedding material.

3.02 PREPARATION:

- A. Sanitary sewer pipe: Hand trim excavations to required elevations. Correct over excavation with stabilization material. Remove large stones or other hard matter which could damage pipe or impede consistent backfilling or compaction.
- B. Manholes: Coordinate placement of inlet and outlet pipe sleeves. Seal exterior surface of sanitary sewer manholes with minimum 14-mil-thick coal tar coating.

3.03 SANITARY SEWER PIPE INSTALLATION:

- A. Maintain separation of sanitary sewers pipe and water mains as indicated in Specification Section 33 10 00.
- B. Install pipe, fittings, and accessories in accordance with ASTM D2321 and manufacturer's instructions. Seal joints watertight.
- C. Lay pipe to slope indicated; with maximum variation from true slope of 1/8-inch in 10 feet. Lay pipe upgrade, with spigot ends pointing in direction of flow. Lay pipe to form a close concentric joint with adjoining section and to prevent sudden offsets in flow line.
- D. Install bedding to depths and dimensions as indicated.
- E. Backfill each section of pipe as it is laid, as specified in Section 31 23 33, and as indicated at least up to centerline, before next joint is made. Do not completely conceal or bury pipe prior to being tested for water tightness and prior to being accepted by the Engineer. Do not displace or damage pipe when compacting.
- F. Clear the interior of the pipe of dirt and superfluous materials as the work progresses. Keep a suitable swab or drag in the pipe and pull it forward past each joint immediately after the jointing has been completed.
- G. Keep trenches and other excavations free of water until final inspection. Do not lay pipe in water. Do not allow water to rise over the work until concrete or grout has had ample time to set.
- H. Close open ends of pipe and fittings in a manner acceptable to the Engineer when the work is not in progress so that trench water, earth and other substances will not enter the pipe or fittings.
- I. Handle pipe and fittings to avoid damage. Carefully inspect pipe and fittings for defects before lowering into the trench.
- J. Where necessary deflect pipelines to avoid obstructions or where long-radius curves are indicated. Do not exceed the maximum deflection recommended by pipe manufacturer. Provide short sections of pipe as necessary to maintain required line.

- K. Connect different types of pipe and accessories with flexible couplings or pipe and accessories with flexible couplings or accepted transition fittings. Provide insulation fittings where ferrous pipe connects to nonferrous metallic pipe.
 - L. Verify invert of each existing pipe prior to commencing work. Prevent debris from entering the pipelines.
 - M. Repair linings, coatings and coverings damaged during construction with accepted materials equal to and compatible with original lining, coating, or covering. Repair damaged galvanizing with zinc-rich paint.
 - N. Connect to building sanitary sewer outlets as indicated on the Contract Drawings.
- 3.04 PRECAST CONCRETE MANHOLE INSTALLATION:
- A. Install precast concrete manholes in accordance with Section 33 95 15.
 - B. Maintain separation of sanitary sewer precast concrete manholes and water mains as indicated in Specification Section 33 10 00.
 - C. Place precast manhole sections plumb and level, adjust to correct elevation. Provide bedding material as indicated and to APWA Utah Chapter standard.
 - D. After manhole assembly, plug lift holes with non-shrink grout.
- 3.05 REPAIR/RESTORATION:
- A. Repair any existing utilities, structures, or features damaged during installation of sanitary sewerage utilities to Owner's satisfaction, and at no cost to Owner.
- 3.06 FIELD TESTING:
- A. General:
 - 1. Perform field-testing under provisions of Section 01 45 23.
 - 2. Request inspection by Owner's Representative prior to and immediately after placing bedding.
 - B. Cleaning and Testing:
 - 1. Test for Displacement of Buried Sanitary Sewers: After trench has been backfilled and compacted, after cover over pipeline has been brought to finished grade, and after debris and silt has been removed, pipelines will be tested by the Engineer, as follows: Light will be flashed between manholes, or, if manholes have not yet been constructed, between locations of manholes, by means of flashlight or by reflecting sunlight with mirror. Correct poor alignment, displaced pipe, and other defects indicated by the Engineer.

2. Test for Deflection of PVC Sanitary Sewers
3. Measure pipelines for vertical ring deflection within 15 days after completion of backfill and at least 4 months after installation, but no later than 30 days before substantial completion of the project. Limit maximum ring deflection of pipeline under load to 5 percent of vertical internal pipe diameter. Relay or replace pipe exceeding this deflection and retest.
4. Use deflectometer that produces continuous record of pipe deflection or pull mandrel, sphere, or pin-type go/no-go device through the pipeline. Make diameter of the go/no-go device 95 percent of undeflected inside diameter of pipe.
5. Testing of Sanitary Sewers: At such times as Engineer may direct, prove watertightness of buried sanitary sewer or portions thereof by one of the following tests. Conduct tests under supervision of the Engineer. Furnish materials, labor, and equipment required for tests and repair system until test results are satisfactory.
6. Infiltration: When, in opinion of the Engineer, trench or excavation is sufficiently saturated by groundwater or rain, tests may be made on basis of infiltration. Infiltration tests will only be allowed when hydrostatic head outside pipe is minimum of 4 feet above crown of pipe for entire length of pipe being tested. Measure flow of water at nearest downgrade manhole. Make three series of measurements at intervals of not less than 1 hour, and average results. Using this average, calculate infiltration rate for 24-hour period. Infiltration rate: Not greater than 100 gallons per inch of pipe diameter per mile per day in any section of system including manholes.
7. Exfiltration: When conditions are not suitable for infiltration test, subject pipe to hydrostatic head of at least 4 feet above pipe crown. Fill line until appropriate water level is obtained at selected upstream manhole. Observe rate of drop at this manhole for 1 hour. Leakage rate: Not to exceed maximum rate allowed for infiltration.
8. Air Test: At Contractor's option, low-pressure air test may be used instead of exfiltration test for vitrified clay, PVC, and concrete pipelines 12-inches and smaller. Perform tests in accordance with ASTM C828 for vitrified clay pipelines, UNI B6 for PVC pipelines, and ASTM C924 for concrete and ductile iron pipelines.
9. Vacuum test: For precast concrete manholes 25 feet deep and less, a vacuum test may be used instead of exfiltration test. Conduct tests prior to backfilling and include joint between manhole cover and frame. Plug and brace pipe openings. Draw vacuum of 10 inches of mercury. Minimum time to drop to 9 inches of mercury follows:

Table 33 30 00-1			
	Manhole Diameter in Inches		
Depth in Feet	48	60	72
Up to 10	60 sec	75 sec	90 sec
10.01-15	75 sec	90 sec	105 sec
15.01-25	90 sec	105 sec	120 sec

10. If manhole fails the test, make necessary repairs, and repeat the vacuum test and repairs until manhole passes test. Submit test results.

3.07 FIELD PAINTING/COATINGS:

- A. Repair any shop painting/coatings damaged during storage or installation to Owner's satisfaction.

3.08 VIDEO INSPECTION:

- A. Immediately after cleaning and testing, video the gravity sewer pipeline to document the condition of the line. Notify the Engineer 24 hours in advance of any video inspection so that the Engineer may observe inspection operations.
- B. Survey video inspection DVDs shall be continuous for pipe segments between manholes. Do not leave gaps in the videotaping of a segment between manholes and do not show a single segment on more than one DVD.
- C. Do not pull or propel the video camera through the line at a speed greater than 30 feet per minute.

3.09 ADJUSTING:

- A. Coordinate with Engineer for any field adjustments. The Engineer reserves the right to reject any field adjustments.

3.10 PROTECTION:

- A. Protect sanitary sewerage utilities from damage throughout storage, installation, testing, and final acceptance.

3.11 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 33 39 15

PRECAST MANHOLES AND STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide precast concrete manholes and structures as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Concrete Institute (ACI):
 - 1. 318: Building Code Requirements for Structural Concrete
- B. ASTM International (ASTM):
 - 1. A48: Standard Specification for Gray Iron Castings
 - 2. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 3. A615: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 4. C478: Standard Specification for Precast Reinforced Concrete Manhole Sections
 - 5. C877: Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
 - 6. C913: Standard Specification for Precast Concrete Water and Wastewater Structures
 - 7. C923: Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
 - 8. C990: Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

1.03 DESIGN REQUIREMENTS:

- A. Equivalent Strength: Based on structural design of reinforced concrete as outlined in ACI 318.
- B. Design of Lifting Devices for Precast Components: In accordance with ASTM C913.

- C. Design of Joints for Precast Components: In accordance with ASTM C913; maximum leakage of 0.025 gallons per hour per foot of joint at 3 feet of head.
- D. Design and install precast concrete manhole and structure to withstand hydrostatic uplift caused by a groundwater elevation at 10 feet below grade level. Use only the weight of the precast manhole and structure and hold-down slab to resist hydrostatic uplift with a minimum safety factor of 1.15. Do not include side friction of soils on walls.

1.04 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Shop Drawings: Indicate precast manhole and structure locations, elevations, piping, and conduit, sizes, and elevations of penetrations.
 - 2. Product Data: Submit cover and frame construction, features, configuration, dimensions.
 - 3. One copy of results of tests and certification reports with each shipment of materials.
 - 4. If manufacturer's test data is inadequate or unavailable, Engineer reserves right to require cores drilled for compressive strength tests.
 - 5. Reinforcing Steel: Certificate of compliance with specifications.
 - 6. Cement: Certificate of compliance with specifications.
 - 7. Aggregates: Certificate of compliance with specifications.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Perform work in accordance with 2017 American Public Works Association (APWA) Standard Plans and Specifications as modified by Provo City 2023 Standard Drawing Details.
- C. Maintain one copy of each document on-site.
- D. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.
- E. Inspection by Engineer:
 - 1. At site of work after delivery.
 - 2. Reject precast concrete manholes and structures at any time if it fails to meet specified requirements, even if accepted at plant.

3. Immediately remove rejected precast concrete manholes and structures from site.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Comply with precast concrete manufacturer's instructions for unloading, storing, and moving precast manholes and structures.
- C. Store precast concrete manholes and structures to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.
- D. Mark each precast manhole and structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Contract Drawings to indicate its intended use.

1.07 PROJECT/SITE CONDITIONS:

- A. Maintain materials and surrounding air temperatures to minimum 50 degrees F prior to, during, and 48 hours after completion of masonry work.
- B. Cold Weather Requirements: ACI 530.

PART 2 - PRODUCTS

2.01 PRECAST CONCRETE MANHOLES AND STRUCTURES:

- A. Manufacturers:
 1. Geneva Pipe and Precast, Inc.
 2. Oldcastle Infrastructure, Inc.
- B. Precast manhole and Structure Sections: Reinforced precast concrete in accordance with ASTM C478 with butyl-rubber sealants, Conseal CS-102 or Ram-Nek RN101 in accordance with ASTM C990. Wrap exterior section joints with membrane waterproofing and exterior joint wrap meeting the requirements of ASTM C877, Type III, Marmac, Conseal CS212, or Press-Seal Corp EA-Wrap.
- C. Pipe Connections: Barrel section to pipe connections shall be sealed with resilient connectors, Kor-N-Seal by Trelleborg, complying with ASTM C923. Mechanical devices shall be stainless steel.

2.02 FRAMES AND COVERS:

- A. Manufacturers:
 1. D&L Supply Company

2. East Jordan Company

3. Neenah Foundry

- B. Product Description: Shall be non-rocking conforming to ASTM A48, Class 30B cast iron construction or ASTM A536, Grade 60-40-18 ductile iron construction. Machined flat bearing surface, removable lid; rated for AASHTO HS-20 loading, unless noted otherwise. Unless noted otherwise, covers and frames shall be 30-inches in diameter, non-vented, machined flat bearing surface, removable lid; with embossed lettering saying "STORM DRAIN" or "SANITARY SEWER" or "IRRIGATION" as applicable cast into cover.
- C. Precast manhole and Structure Steps: ASTM C478. Precast manhole steps shall have a 1/2-inch ASTM A615 grade 60 steel reinforcement rod encased in polypropylene copolymer plastic. Steps shall have a tread width of 14-inches (nominal), contoured to fit the hand for comfort, and a sure grip sturdy tread design with side molded slip-resistant wings. Steps shall be manufactured by American Step Company, Inc., or M.A. Industries.
- D. Base Pad: Cast-in-place concrete of type specified in Section 03 30 00, leveled top surface or precast concrete base section.

2.03 CONFIGURATION:

- A. Shaft Construction: Concentric with eccentric cone or flat top section; lipped male/female dry joints; sleeved to receive pipe and conduit sections.
- B. Shape: Cylindrical, Square, or Rectangular, as indicated on the Contract Drawings.
- C. Clear Inside Dimensions: As indicated on Contract Drawings.
- D. Design Depth: As indicated on Contract Drawings.
- E. Clear Cover Opening: 30 inches diameter minimum or as indicated on Contract Drawings.
- F. Pipe and/or Conduit Entry: Furnish openings as indicated on the Contract Drawings. Barrel section to pipe connections shall be sealed with resilient connectors, Kor-N-Seal by Trelleborg; Press-Seal Corporation; or A-Lok Products, Inc., complying with ASTM C923. Mechanical devices shall be stainless steel.
- G. Steps: 14 inches wide, 12 inches on center vertically, set into precast manhole and structure wall.

2.04 BEDDING AND COVER MATERIALS:

- A. Bedding: Fill Type as specified in Section 31 23 00.
- B. Cover: Fill Type, as specified in Section 31 23 00.

- C. Soil Backfill from Above Pipe to Finish Grade: Soil Type, as specified in Section 31 23 00. Subsoil with no rocks over 6 inches in diameter, frozen earth, or foreign matter.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verification of existing conditions before starting work.
- B. Verify items provided by other sections of Work are properly sized and located.
- C. Verify built-in items are in proper location, and ready for roughing into Work.
- D. Verify correct size of precast manhole and structure excavation.

3.02 PREPARATION:

- A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.
- B. Do not install structures where site conditions induce loads exceeding structural capacity of structures.
- C. Inspect precast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage. Remove and replace damaged units.

3.03 INSTALLATION:

- A. Excavation and Backfill:
 - 1. Excavate for precast manholes and structures in accordance with Section 31 23 00 in location and to depth shown. Provide clearance around sidewalls of structure for construction operations.
 - 2. When groundwater is encountered, prevent accumulation of water in excavations. Place precast manholes and structures in dry trench.
 - 3. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation.
- B. Place base pad, trowel top surface level.
- C. Place precast manhole and structure sections plumb and level, trim to correct elevations, anchor to base pad.
- D. Backfill excavations for precast manholes and structures in accordance with Section 31 23 00.

- E. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour to form continuous drainage channel as indicated on the Contract Drawings.
- F. Set cover frames and covers level without tipping, to correct elevations.
- G. Coordinate with other sections of Work to provide correct size, shape, and location.

3.04 PRECAST CONCRETE MANHOLE AND STRUCTURE INSTALLATION:

- A. Lift precast components at lifting points designated by manufacturer.
- B. When lowering precast manhole and structures into excavations and joining pipe to units, take precautions to ensure interior of pipeline and structure remains clean.
- C. Set precast structures bearing firmly and fully on crushed stone bedding, compacted in accordance with provisions of Section 31 23 00 or on other support system shown on the Contract Drawings.
- D. Assemble multi-section structures by lowering each section into excavation. Lower, set level, and firmly position base section before placing additional sections.
- E. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.
- F. Joint sealing materials may be installed on site or at manufacturer's plant.
- G. Verify precast manholes and structures installed satisfy required alignment and grade.
- H. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe. Fill annular space with mortar.
- I. Cut pipe to finish flush with interior of structure.
- J. Install exterior joint wrap per manufacturer's written installation instructions. Wrap shall extend 12 inches above and 12 inches below the joint.
- K. Shape inverts through precast manhole and structures as shown on the Contract Drawings.

3.05 CAST-IN-PLACE CONCRETE STRUCTURE INSTALLATION:

- A. Prepare crushed stone bedding or other support system shown on the Contract Drawings, to receive base slab as specified for the structures.
- B. Erect and brace forms against movement in accordance with Section 03 10 00.
- C. Install reinforcing steel as indicated on the Contract Drawings and in accordance with Section 03 21 00.

- D. Place and cure concrete in accordance with Section 03 30 00.

3.06 FRAME AND COVER INSTALLATION:

- A. Set frames using precast concrete grade rings. Maximum height of grades rings shall be 12 inches.
- B. Set frame and cover 2 inches above finished grade for precast manholes and structures with covers located within unpaved areas to allow area to be graded away from cover beginning 1 inch below top surface of frame.

3.07 FIELD QUALITY CONTROL:

- A. Section 01 43 00: Field inspecting, testing, adjusting, and balancing.
- B. Test cast-in-place concrete in accordance with Section 03 30 00.
- C. Vertical Adjustment of Existing Precast Manholes and Structures:
 - 1. Where required, adjust top elevation of existing precast manholes and structures to finished grades shown on the Contract Drawings.
 - 2. Reset existing frames, grates and covers, carefully removed, cleaned of mortar fragments, to required elevation in accordance with requirements specified for installation of castings.
 - 3. Remove concrete without damaging existing vertical reinforcing bars when removal of existing concrete wall is required. Clean vertical bars of concrete and bend into new concrete top slab or splice to required vertical reinforcement, as indicated on the Contract Drawings.
 - 4. Clean and apply sand-cement bonding compound on existing concrete surfaces to receive cast-in-place concrete in accordance with Section 03 30 00.
- D. Precast Concrete Precast Manhole Test:
 - 1. Vacuum test: For precast concrete precast manholes 25 feet deep and less, a vacuum test may be used instead of exfiltration test. Conduct tests prior to backfilling and include joint between precast manhole cover and frame. Plug and brace pipe openings. Draw vacuum of 10 inches of mercury. Minimum time to drop to 9 inches of mercury follows:

Table 33 39 15-1			
	Precast manhole Diameter in Inches		
Depth in Feet	48	60	72
Up to 10	60 sec.	75 sec.	90 sec.
10.01-15	75 sec.	90 sec.	105 sec.
15.01-25	90 sec.	105 sec.	120 sec.

2. If precast manhole fails the test, make necessary repairs, and repeat the vacuum test and repairs until precast manhole passes test. Submit test results.

3.08 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 33 40 00

STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide storm drainage utilities as indicated and in compliance with Contract Documents.
- B. This section specifies storm drainage systems from 5 feet outside the building and excludes interceptors, storm separators, or sub-drainage.
- C. Section includes:
 - 1. Storm drainage piping, fittings, and accessories.
 - 2. Storm drainage catch basins, inlets, area drains, manholes or other structures.

1.02 REFERENCES:

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. M198: Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
- B. ASTM International (ASTM):
 - 1. C76: Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
 - 2. C150: Standard Specification for Portland Cement.
 - 3. C443: Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
 - 4. C478: Standard Specification for Precast Reinforced Concrete Manhole Sections.
 - 5. C858: Standard Specification for Underground Precast Concrete Utility Structures
 - 6. C890: Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
 - 7. C913: Standard Specification for Precast Concrete Water and Wastewater Structures
 - 8. C923: Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.

9. C990: Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
10. C1103: Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
11. D1785: Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
12. D2729: Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
13. D3034: Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
14. D3212: Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
15. D4097: Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
16. F477: Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
17. F679: Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
18. F1417: Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air

1.03 DEFINITIONS:

- A. Catch Basin or Catchbasin: A special type of inlet structure designed to retain sediment and debris transported by stormwater into the storm drainage system.

1.04 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00.
 1. Shop Drawings:
 - a. Precast Concrete Structures: Indicate locations, dimensions, configuration, thicknesses, elevations, sizes, and penetration elevations.
 2. Product Data:
 - a. Pipe: Material, pipe accessories, and manufacturer's installation instructions.

3. Certificates: Manufacturer's certificate stating that product meets or exceeds specified requirements.
4. Project Record Documents: Provide record drawings of actual pipe run locations, connections, structures, and invert elevations.
5. Testing results.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Perform work in accordance with the "Manual of Standard Plans and Specification – APWA Utah Chapter and Specifications as modified by Provo City 2023 Standard Drawing Details.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PIPE MATERIALS:

- A. Reinforced Concrete Pipe (RCP):
 1. Pipe: ASTM C76, minimum Class III, unless noted otherwise; nominal inside diameter as indicated.
 2. End Joints: Bell and spigot for pipes 12-inch diameter through 48-inch diameter. Tongue and groove for pipes 60-inch diameter and larger.
 3. Joint Device:
 - a. Watertight: ASTM C443, rubber compression gasket.
 - b. Manufacturer or approved equal:
 - (1) Geneva Pipe and Precast
 - (2) Oldcastle Infrastructure
- B. Plastic Pipe (PVC):
 1. Pipe (4-inch through 15-inch diameter): ASTM D3034, Type PSM PVC material; minimum SDR35, nominal inside diameter as indicated.

2. Pipe (18-inch through 48-inch diameter): ASTM F679, Type PSM PVC material; minimum pipe stiffness 46 psi, nominal inside diameter as indicated.
3. End Joints: Bell and spigot per ASTM D3212.
4. Joint Device: Gasket Flexible elastomeric locked-in gasket per ASTM F477.
5. Manufacturer:
 - a. JM Eagle
 - b. Vinyltech
 - c. Diamond Plastics Corporation

2.02 CATCH BASINS:

- A. Cast-in-place drainage structure per APWA Plan 315.1.
- B. Minimum sump depth is 12 inches, unless noted otherwise.
- C. Steps: None.
- D. Grating: Per APWA Plan 308. Bicycle friendly, gray iron ASTM A48 Class 35B grate for H-20 traffic loading with asphalt-based coating.
 1. Manufacturer:
 - a. D&L Supply
 - b. East Jordan
 - c. Neenah Foundry

2.03 CLEANOUT BOXES:

- A. Cast-in-place drainage structure per APWA Plan 331.2, Type B.
- B. Minimum sump depth is 12 inches, unless noted otherwise.
- C. Steps: Required in boxes greater than 4 feet deep.
- D. Ring and Cover: 30-inch per APWA Plan 302.1.

2.04 AREA DRAINS:

- A. Precast drainage structure per ASTM C858 or ASTM C913.
- B. Loading: H-20 traffic loading.

C. Grating: Steel frame to be cast into concrete riser or base. Bicycle friendly, gray iron ASTM A48 Class 35B grate for H-20 traffic loading with asphalt-based coating.

1. Manufacturer:

- a. D&L Supply
- b. East Jordan
- c. Neenah Foundry

D. Minimum sump depth is 12 inches, unless noted otherwise.

E. Steps: None.

F. Manufacturer:

- 1. Harper Precast, Inc.
- 2. Geneve Pipe and Precast, Inc.
- 3. Oldcastle Infrastructure, Inc.

2.05 PRECAST MANHOLES:

A. Manhole Sections: Circular reinforced precast concrete in accordance with ASTM C478. Manhole diameter shall be as indicated on the Contract Drawings. Axial length of barrel sections shall be selected to provide the correct total height with the fewest joints. Conical sections shall be designed to support cast iron frames and covers under H-20 loading, unless noted otherwise.

1. Manufacturer:

- a. Geneva Pipe and Precast, Inc.
- b. Oldcastle Infrastructure, Inc.

B. Pipe Connections: Barrel section to pipe connections shall be sealed with resilient connectors, Kor-N-Seal by Trelleborg, complying with ASTM C923. Mechanical devices shall be stainless steel.

C. Joints: Water-tight joints shall be sealed with butyl-rubber sealants, ConSeal CS-102 or Ram-Nek RN101 conforming to ASTM C990.

D. Per Section 33 95 15.

2.06 CAST-IN-PLACE STRUCTURES:

A. Materials:

1. Concrete: Section 03 30 00, minimum compressive strength of 4,000 psi.
2. Portland Cement: ASTM C150, Type II.
3. Hydrated Lime: ASTM C207, Type S.
4. Sand: ASTM C33, Fine Aggregate, except all passes No. 8 sieve.
5. Water: Potable, not detrimental to concrete.

2.07 MIXES:

- A. Mortar for Plugging Lift Holes: Mix Portland cement and sand, 1 part cement to 1/2-part sand with sufficient water to make mortar damp without "balling".

2.08 COMPONENTS:

- A. Frame and Cover: Shall be non-rocking conforming to ASTM A48, Class 30B cast iron construction or ASTM A536, Grade 60-40-18 ductile iron construction. Machined flat bearing surface, removable lid; rated for AASHTO HS-20 loading, unless noted otherwise. Unless noted otherwise, covers and frames shall be 30-inches in diameter, non-vented, machined flat bearing surface, removable lid; with embossed lettering saying "STORM DRAIN" or "IRRIGATION" cast into cover.

1. Manufacturer:

- a. D&L Supply Company
- b. East Jordan Company
- c. Neenah Foundry

2. Castings shall be as follows:

- a. Free from scale, lumps, blisters, and sandholes.
- b. Machine contact surfaces to prevent rocking.
- c. Thoroughly clean and hammer inspect.

- B. Manhole Steps: ASTM C478. Manhole steps shall have a 1/2-inch ASTM A615 grade 60 steel reinforcement rod encased in polypropylene copolymer plastic. Steps shall have a tread width of 14-inches (nominal), contoured to fit the hand for comfort, and a sure grip sturdy tread design with side molded slip-resistant wings. Steps shall be manufactured by American Step Company, Inc., or M.A. Industries.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify items provided by other sections of Work are properly sized and located.
- B. Verify built-in items are in proper location, and ready for roughing into Work.
- C. Verify correct size of manhole and structure excavation.

3.02 PREPARATION:

- A. Do not install structures where site conditions induce loads exceeding structural capacity of structures.
- B. Inspect precast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage. Remove and replace damaged units.

3.03 TRENCHING:

- A. See Section 31 23 23 for additional requirements.
- B. Hand trim excavation for accurate placement of pipe to indicated elevations.

3.04 CATCH BASINS AND CLEANOUTS:

- A. Form bottom of excavation, clean and smooth and to correct elevation.
- B. Provide bedding in accordance with Section 31 23 00.
- C. Place structure plumb and level on prepared bedding.
- D. Orient structure for pipe connections.
- E. Form and place cast-in-place concrete base pad.
- F. Level the top surface of base pad and sleeve concrete shaft sections to receive storm drainage pipe sections.
- G. Establish elevations and pipe inverts as indicated.
- H. Establish top elevation and mount frame and cover.
- I. Mount frame level in grout, secured to top cone section.

3.05 PRECAST STRUCTURES:

- A. Provide bedding according to Section 31 23 00.

- B. Lift precast components at lifting points designated by the manufacturer.
- C. Assemble multi-section structures by lowering each section into excavation. Lower, set level, and firmly position base section before placing additional sections.
- D. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.
- E. Joint sealing materials may be installed on site or at manufacturer's plant.
- F. Verify manholes installed plumb and level and satisfy required alignment and grade.
- G. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe or flexible connector.
- H. Steps shall be installed 12-inches on centers vertically not more than 1/2-inch out of plumb. The top step shall not be more than 12-inches below the manhole cover. Prior to backfilling, fill all cracks and voids in the manholes or vaults with non-shrink grout, polyurethane sealant, or both.

3.06 FIELD QUALITY CONTROL:

- A. Remove work that does not pass tests; replace and retest until successful installation is achieved.
- B. General:
 - 1. Perform field-testing under provisions of Section 01 45 33.
 - 2. Request inspection by Engineer prior to placing bedding.
- C. Displacement Test:
 - 1. After trench has been backfilled and compacted, after cover over pipeline has been brought to finished grade, and after debris and silt has been removed Engineer will visually inspect pipe. Pipes that do not present a uniform bore due to displacement and misalignment shall be replaced.
- D. Deflection Test:
 - 1. Test pipes for vertical ring deflection within 15 days after completion of backfill and again at least 4 months after installation but not later than 30 days before estimated substantial completion.
 - 2. Maximum allowable ring deflection is 5 percent of vertical internal pipe diameter.
 - 3. Replace pipe exceeding this allowable deflection.

- E. Make deflection tests with deflectometer which produces a continuous record of pipe deflection by pulling mandrel, sphere, or pin-type go/no-go device through pipe. Make the diameter of go/no-go device to be 95 percent of the undeflected inside pipe diameter.
- F. Vertical Adjustment of Existing Manholes and Structures:
1. Where required, adjust top elevation of manholes and structures to finished grades shown on Contract Drawings.
 2. Reset existing frames, grates and covers, carefully removed, cleaned of mortar fragments, to required elevation in accordance with requirements specified for installation of castings.
- G. Cleaning and Testing:
1. Testing of Storm Drainage Utilities: At such times as Engineer may direct, prove watertightness of buried storm drainage utilities or portions thereof by one of the following tests. Conduct tests under supervision of the Engineer. Furnish materials, labor, and equipment required for tests and repair system until test results are satisfactory.
 2. Infiltration: When, in opinion of the Engineer, trench or excavation is sufficiently saturated by groundwater or rain, tests may be made on basis of infiltration. Infiltration tests will only be allowed when hydrostatic head outside pipe is minimum of 4 feet above crown of pipe for entire length of pipe being tested. Measure flow of water at nearest downgrade manhole. Make three series of measurements at intervals of not less than 1 hour, and average results. Using this average, calculate infiltration rate for 24-hour period. Infiltration rate: Not greater than 100 gallons per inch of pipe diameter per mile of pipe per day in any section of system including manholes.
 3. Exfiltration: When conditions are not suitable for infiltration test, subject pipe to hydrostatic head of at least 4 feet above pipe crown. Fill line until appropriate water level is obtained at selected upstream manhole. Observe rate of drop at this manhole for 1 hour. Leakage rate: Not to exceed maximum rate allowed for infiltration.
 4. Air Pressure Test:
 - a. Air testing for sections of pipe shall be limited to lines less than 36-inch average inside diameter.
 - b. Lines 36-inch average inside diameter and larger shall be "joint" tested at each joint. The minimum allowable for the pressure drop from 3.5 psig to 2.5 psig during a joint test shall be 10 seconds, regardless of pipe size. Joint test shall be conducted as follows:
 - (1) Each joint shall be tested successfully.

- (2) Joint tester shall be set over joint to be tested so that the two inflation tubes straddle the joint.
 - (3) Inflate tubes to 25 psig to seal off joint to be tested.
 - (4) Apply air pressure into void between inflation tubes until pressure reaches 4 psig.
 - (5) After pressure has stabilized, bleed air pressure back to 3.5 psig.
 - (6) Record time required for pressure to drop from 3.5 psig to 2.5 psig.
 - (7) If the time in seconds for the air pressure to decrease from 3.5 psig to 2.5 psig is greater than 10 seconds, the joint shall be presumed to be free from defect. When the time is less than 10 seconds pipe breakage, joint leakage, or leaking testing seals are indicated and an inspection must be made to determine the cause. The Contractor shall affect such repairs as may be required to accomplish a successful air joint test.
- c. For pipe sections less than 36-inch average inside diameter:
- (1) Determine the groundwater level.
 - (2) Plug both ends of the pipe. For concrete pipe, flood pipe and allow 2 hours to saturate concrete. Then drain and plug pipe.
 - (3) After a manhole-to-manhole section of pipe has been sliplined and prior to any services lines being connected to new liner, plug liner at each manhole with pneumatic plugs.
 - (4) Pressurize pipe to 4.0 psig. Increase pressure 1.0 psi for each 2.3 feet of ground water over highest point in the system. Allow pressure to stabilize for 2 to 4 minutes. Adjust pressure to start at 3.5 psig (plus adjustment for ground water table). See Table 33 40 00-2 at the end of this Section.
 - (5) To determine air loss, measure the time interval for pressure to drop to 2.5 psig. The time must exceed that listed in the Table 33 40 00-2 at the end of this Section for pipe diameter and length. For sliplining, use diameter of carrier pipe.
- d. The test of the pipe and service laterals shall be conducted in the presence of the Engineer. Testing of pipe, regardless of the pipe material, shall be performed in accordance with ASTM C828 or ASTM F1417, as applicable.
- e. Any section of pipe which fails to meet requirements shall be repaired and retested.

5. Vacuum test: For precast concrete manholes 25 feet deep and less, a vacuum test may be used instead of exfiltration test. Conduct tests prior to backfilling and include joint between manhole cover and frame. Plug and brace pipe openings. Draw vacuum of 10 inches of mercury. Minimum time to drop to 9 inches of mercury follows:

Table 33 40 00-1			
	Manhole Diameter in Inches		
Depth in Feet	48	60	72
Up to 10	60 sec.	75 sec.	90 sec.
10.01-15	75 sec.	90 sec.	105 sec.
15.01-25	90 sec.	105 sec.	120 sec.

6. If manhole fails the test, make necessary repairs, and repeat the vacuum test and repairs until manhole passes test. Submit test results.

3.07 VIDEO INSPECTION:

- A. Immediately after cleaning and testing, video the storm drainage pipeline to document the condition of the line. Notify the Engineer 24 hours in advance of any video inspection so that the Engineer may observe inspection operations.
- B. Survey video inspection DVDs shall be continuous for pipe segments between manholes. Do not leave gaps in the videotaping of a segment between manholes and do not show a single segment on more than one DVD.
- C. Do not pull or propel the video camera through the line at a speed greater than 30 feet per minute.

3.08 ALIGNMENT AND GRADE TEST:

- A. Line and grade of pipe may not vary more than 1/2 inch in 10 feet and not more than 1-inch variance from true line at any location.
- B. Grade of pipe may not vary more than 1/4 inch in 10 feet for all design grades less than or equal to 1 percent and not more the 1/2-inch total variance from true grade at any location. Also, grade of pipe may not vary more than 1/2 inch in 10 feet for all design grades greater than 1 percent and not more than 1-inch total variance from true grade at any location. These tolerances shall be acceptable provided that such variation does not result in a level or reverse sloping invert.
- C. The variation in the invert elevation between adjoining ends of pipe due to eccentricity of joining surface and pipe interior surfaces shall not exceed 1/64 inch per inch of pipe diameter, or 1/4 inch maximum.

3.09 PROTECTION:

- A. Protect pipe and bedding from damage or displacement until backfilling operation is completed.

3.10 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

TABLE 33 40 00-2												
Pipe Diameter (inch)	Minimum Time (min:sec)	Length for Minimum Time (ft)	Time for Longer Length (sec/ft)	Specification Time for Length (L) Shown (min:sec)								
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft	500 ft
6	5:40	398	0.8548	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:25	7:07
8	7:33	298	1.5196	7:33	7:33	7:33	7:33	7:36	8:52	10:08	11:24	12:40
10	9:27	239	2.3743	9:27	9:27	9:27	9:54	11:52	13:51	15:50	17:48	19:47
12	11:20	199	3.4190	11:20	11:20	11:20	14:15	17:06	19:57	22:48	25:39	28:30
15	14:10	159	5.3423	14:10	14:10	17:48	22:16	26:43	31:10	35:37	40:04	44:31
18	17:00	133	7.6928	17:00	19:14	25:39	32:03	38:28	44:52	51:17	57:42	64:06
21	19:50	114	10.4708	19:50	26:11	34:54	43:38	52:21	61:05	69:48	78:32	87:15
24	22:40	99	13.6762	22:48	34:11	45:35	56:59	68:23	79:47	91:10	102:34	113:58
27	25:30	88	17.3089	28:51	43:16	57:42	72:07	86:33	100:58	115:24	129:49	144:14
30	28:20	80	21.3690	35:37	53:25	71:14	89:02	106:51	124:39	142:28	160:16	178:05
33	31:10	72	25.8565	43:06	64:38	86:11	107:44	129:17	150:50	172:23	193:55	215:28

END OF SECTION

SECTION 40 05 90.02

STAINLESS STEEL SLIDE GATES AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide and test stainless steel slide gates and appurtenances as indicated and in compliance with Contract Documents.
- B. Gates and appurtenances installed inside the Clearwell shall be NSF 61 certified.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
 - 2. A276: Standard Specifications for Stainless Steel Bars and Shapes.
 - 3. B584: Standard Specification for Copper Alloy Sand Castings for General Applications.
 - 4. D2000: Standard Classification System for Rubber Products in Automotive Applications.
 - 5. D4020: Standard Specification for Ultra-High-Molecular-Weight Polyethylene Molding and Extrusion Materials
- B. American Welding Society Code.
- C. American Water Works Association (AWWA):
 - 1. C561: Fabricated Stainless Steel Slide Gates
- D. NSF International (NSF):
 - 1. 61: Drinking water system components Health effects

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00:
 - 1. Certified shop and erection drawings. Contractor shall submit electronic files of the proposed equipment in the capacity, size, and arrangement as indicated and specified.

2. Data for gate and actuator characteristics and performance.
3. Complete description of all materials, material thicknesses of all components.
4. Maximum bending stress and deflection of the slide under design head specified and indicated.
5. Installation drawings showing the details required for installation, dimensions, clearances, and anchor bolt locations.
6. Shop drawing data for accessory items.
7. Certified setting plans, with tolerances, for anchor bolts.
8. Manufacturer's literature as needed to supplement certified data.
9. Operating and maintenance instructions and parts lists.
10. For manufacturers not named provide a listing of reference installations as specified with contact names and telephone numbers.
11. Certified results of gate shop testing, including shop leakage test results of each gate at the design unseating head specified and indicated.
12. Certified results of actuator shop testing from the actuator manufacturer.
13. List of recommended spare parts other than those specified.
14. Shop and field inspection reports.
15. Qualifications of field service engineer.
16. Recommendations for short and long-term storage.
17. Shop and field testing procedures and set up
18. Special tools.
19. Manufacturer's product data, specifications, and color charts for shop painting.
20. Motor shop test results.
21. The latest ISO 9001 series certification or quality system plan.
22. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are

proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.

- b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
 - B. A copy of the contract mechanical process, structural, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required" or provide a statement that no changes are required.
 - 1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
 - C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - 1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.
- 1.04 SPARE PARTS
- A. Comply with the requirements specified in Section 01 61 00.
 - 1. One set of all special tools.
- 1.05 QUALITY ASSURANCE
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Gates shall be the product of one manufacturer.

- C. Gates shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.
- D. Slide gates and appurtenances must be fabricated, assembled, and tested in the United States of America or Canada.
- E. Welding: In accordance with latest applicable American Welding Society Code, ASME Welding Code, or equivalent.
- F. Shop tests as specified, including shop leakage testing of each gate at the design unseating head to confirm compliance with the leakage rate specified and indicated.
- G. The Contractor shall obtain the gates, actuators, and appurtenances from the gate manufacturer, as a complete and integrated package to insure proper coordination and compatibility and operation of the system.
- H. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.
- I. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 - 2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of electrical connection:
 - a. 1 person-days.
 - 3. Functional Testing: Calibrate, check alignment, and perform a functional test. Tests to include all items specified.
 - a. 1 person-days.
 - 4. Field Performance Testing: Field performance test equipment specified.
 - a. 1 person-days.
 - 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts, and preparation to lead and teach classroom sessions.
 - a. 0.5 person-days.
 - 6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.

7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
 - J. Manufacturer of gates shall have a minimum of five (5) operating installations with gates of the size specified and in the same service as specified operating for not less than five (5) years or manufacturer of gates shall utilize a Project Manager that is experienced in stainless steel gate design and construction. The Project Manager shall be an employee of the gate manufacturer and shall have designed a minimum of five (5) operating installations with gates of the size specified and in the same service as specified operating for not less than five (5) years.
- 1.06 DELIVERY, STORAGE AND HANDLING
- A. Comply with the requirements specified in Section 01 66 10.
 - B. Ship electric actuators separate from the gate assembly.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. Gate sizes and operating data are indicated on the Contract Drawings.

2.02 MANUFACTURERS

- A. Stainless Steel Slide Gates:
 1. Whipps, Inc. Series 900
 2. Waterman Valve (McWane) SS-250 Series
 3. Fresno Valves and Castings, Inc. Series 8200
 4. Golden Harvest, Inc. (for Diversion Box only)
 5. RW Gate Co.
 6. Acceptable Equivalent Product with unitized single piece frame.
 - a. Provide in accordance with Section 01 25 00.

2.03 SEISMIC DESIGN REQUIREMENTS

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.

- B. The Contractor shall conform to the seismic design requirements for this project and for the work of this specification section.
- C. Provide all equipment bases, anchorage, supports and foundations designed in accordance with the seismic requirements indicated and specified.
- D. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were performed and that all components have been sized for the seismic forces specified and indicated.

2.04 SLIDE GATE CONSTRUCTION

- A. Provide all gates produced by a single manufacturer and designed for installation in the channels and structures as specified and indicated. Gates installed in the Clearwell shall be NSF 61 certified.
- B. Gate Configuration: As indicated on the Contract Drawings.
- C. Provide all gates in conformance with AWWA C561 and as specified.
- D. Self-contained, rising, or non-rising stem, flush bottom type with self-adjusting seals.
- E. Gates with adjustable wedges or wedging devices are not acceptable.
- F. Provide all structural components 1/4-inch minimum thickness.
- G. Gate assemblies shall be media blasted or mechanically descaled by grinding and passivated in accordance with ASTM A380 prior to shipment to remove all mill scale, weld splatter, discoloration, or other surface imperfections.
- H. Leakage Rate:
 - 1. Seating head and unseating head conditions: Leakage not to exceed 0.05 gpm per foot of seating perimeter.
- I. Assembly to consist of the following:
 - 1. Frame.
 - 2. Slide.
 - 3. Stem.
 - 4. Seals.
 - 5. Benchstand with operator type as indicated on the Contract Drawings.

J. Materials:

1. Frame Assembly and Retainers: ASTM A240 Type 316L stainless steel.
2. Slides and Stiffeners: ASTM A240 Type 316L stainless steel.
 - a. 1/4-inch minimum thickness.
3. Seat, Seals and Facing: ASTM D4020 UHMW (Ultra-high Molecular Weight Polyethylene
4. Invert Seal for upward acting gates only: ASTM D2000 Neoprene or EPDM
5. Stems: ASTM A276 Type 316 stainless steel.
 - a. Minimum diameter: 1-1/2-inch.
6. Lift Nuts: ASTM B584 Bronze
7. Floorstand and Wall Brackets: ASTM A276 Type 316L stainless steel
8. Gear Operator Housing: Cast aluminum, cast iron, or ductile iron.
9. Hardware, studs, and nuts: ASTM A276 Type 316 stainless steel.
10. Anchor bolts: Type 316 stainless steel. Minimum diameter of 1/2-inch.

K. Slide:

1. Slide and reinforcing stiffeners welded to the slide.
 - a. Stainless steel plate, minimum 1/4-inch.
 - b. Reinforcement: Provide a minimum of two horizontal stiffeners welded to the slide and two vertical stiffeners welded to outside of the horizontal stiffeners.
 - c. Provide slide to engage the guide a minimum of 1 inch on each side and have a minimum material thickness of a 1/4 inch,
 - (1) Gates with the width of the gate opening x maximum design head is 80 ft² or greater, provide the portion of the slide that engages the guide members either 1/4-, 3/8-, or 1/2-inch-thick edge design where it engages the guide.
 - (2) Gates with the width of the gate opening x maximum design head is 120 ft² or greater, provide the portion of the slide that engages the guide members 3-inch-thick edge design where it engages the guide or provide standard design with supporting calculation.

- d. Provide the stem connector constructed of two angles or plates welded to the slide. Provide a minimum of two bolts connecting the stem to the stem connector.
2. Deflection: Maximum of $1/720$ of the span or $1/16$ inch whichever is smaller, under design head specified.

L. Seals:

1. Provide a self-adjusting seal system suitable for the leakage, frequent cycling and velocities specified herein, and mounted such that there is no obstruction to the specified gate opening size.
2. Provide gates equipped with UHMW polyethylene seat/seals to restrict leakage and to prevent metal to metal contact between the frame and slide.
3. Extend the seat/seals to accommodate the $1.50 \times$ the slide height with the gate in the fully open or fully closed position.
4. Provide all upward opening gates with a resilient flush bottom seal for sealing the invert of the gate.
5. Provide all downward opening weir gates with self-adjusting UHMW seat/seals across the invert member.
6. Provide all seals mechanically fastened to the frame or slide, force fit seals or seals attached with adhesive are not acceptable.
7. Provide all seats and seals to be field replaceable without the need to remove grout or concrete and without the need to remove the frame from the wall or wall thimble.
8. Gates using "J" or "P" seals are not acceptable.

M. Frames:

1. Provide frame assembly including guide members, invert members and yoke members constructed of formed stainless steel plate with a minimum thickness of $1/4$ -inch.
2. Provide gussets to support the guide members for unseating gates as required by the design head specified and indicated.
 - a. Provide gussets extended to support the outer portion of the guide assembly and positioned to transfer the load to the anchor bolts or the wall thimble studs.
3. Provide frames for mounting type as indicated on the Contract Drawings.
 - a. Embedded

- b. Wall mounted with stainless steel anchor bolts and non-shrink, non-metallic grout or EPDM gasket.
 - c. Thimble mounted with stainless steel mounting studs and mastic gasket.
- 4. Provide all wall mounted and thimble mounted gates with a flanged frame. Flat frame gates are not acceptable.
- 5. Provide all wall mounted and wall thimble mounted frames with a minimum guide weight of 11 lbs/ft and a minimum guide extension weight of 6.5 lbs/ft.
- 6. Provide guide extensions constructed of C-channel shape or similar. Angles are acceptable guide extensions.
- 7. Frame Guides and Invert Members: Provide frames as a unitized, fully welded assembly.
 - a. Bolt-on yokes are acceptable when necessary to facilitate slide removal.
 - b. Frames that require field assembly are not acceptable unless the overall frame size exceeds a size suitable for shipment on a standard flatbed truck.
- 8. Provide the frame guides extending to accommodate the entire height of the slide when the slide is in the fully opened position on upward opening slide gates or downward opening weir gates.
- 9. For self-contained gates, provide a yoke across the top of the frame guides with the yoke formed by two structural members fixed to the top of the guides to provide a one-piece rigid frame.
 - a. Provide the yoke designed to allow removal of the slide.
- 10. Provide a rigid stainless steel invert member across the bottom of the opening.
 - a. Invert member: Flush bottom type on upward opening gates with a minimum weight as specified
- 11. Provide a rigid stainless steel top seal member across the top of the opening on gates designed to cover submerged openings.
- 12. Provide a rigid stainless steel member across the invert of the opening on downward opening weir gates.

N. Stems:

- 1. Provide a threaded operating stem to connect the operating mechanism to the slide.
- 2. For rising stem gates provide the threaded portion engaging the operating nut in the manual operator or motor actuator.

3. For non-rising stem gates provide the threaded portion engaging the nut on the slide.
4. Minimum stem outside diameter of 1-1/2 inches.
5. Stem extension pipes are not acceptable.
6. Provide the stem constructed of solid stainless-steel bar for the entire length.
7. Tensile strength: Not less than 60,000 psi for stems.
8. Provide the stem threaded to allow full travel of the slide unless otherwise specified or indicated.
9. L/R: Not to exceed 200.
10. Provide the stem in accordance with AWWA C561, to withstand in tension the loads caused by an 80 pound effort on the manual crank or handwheel without exceeding 25 percent of the ultimate tensile strength of the stem material.
11. Motor Operators: Design stems to withstand in compression 1.30 x stalled output.
12. Provide the stem, in tension, designed to withstand a load caused by a 40-pound effort on the crank or handwheel without exceeding 1/5 of the ultimate tensile strength of the stem material.
13. Provide the threaded portion of the stem machined rolled or cut full depth ACME type threads with 16 micro-inch or better finish. Stub threads are not acceptable.
14. Provide stems of more than one piece joined by bronze or stainless-steel couplings with the coupling bolted to the stem.
15. Provide dual stems for upward opening gates wider than 60-inch when the opening width is 2 x greater or more than the height of the slide. Provide dual stems for downward opening gates wider than 48 inches when the opening width is 2 x greater or more than the height of the slide.
16. Provide stems on manually operated gates with an adjustable stop collar to prevent over closing of the gate.
17. For rising stem gates, provide clear plastic covers with 1-inch graduations. Provide vent holes to prevent condensation.

2.05 2.05 STEM GUIDES

- A. Provide stem guides where required to maintain L/R of 200 or less for the unsupported length of the stem
- B. Provide stem guides and brackets of Type 316L stainless steel.

1. Adjustable in two directions
2. Minimum Thickness: 1/4-inch.
3. Bushings: UHMW or bronze

2.06 WALL THIMBLES

- A. Provide where indicated on the Contract Drawings.
 1. Provide “F” thimbles for all systems not connected to piping systems.
 2. Provide “E” thimbles for all gates connected to piping systems.
 3. Provide MJ thimbles where indicated.
- B. Provide “E” thimble depth equal to the thickness of the concrete wall in which the thimble is to be mounted.
- C. For “F” thimbles in walls 36 inch thick and smaller provide thimble depth equal to the thickness of the concrete wall in which the thimble is to be mounted. For walls 36 inches thick and larger provide a minimum of 36-inch deep “F” thimble.
- D. Provide a water stop continuously welded or stitch welded and sealed on both sides around the periphery of the thimble.
- E. Provide wall thimbles of fabricated Type 316L stainless steel construction of adequate section to withstand all operational and installation stresses.
 1. Minimum thickness including front face: 1/4-inch.
- F. Provide the thimble square and plumb and the front face sufficiently flat to provide a mounting surface for the gate frame to achieve the specified leakage rate.
- G. Provide the face of the wall thimble machined if recommended by the gate manufacturer. If the wall thimble is to be machined provide the front face with a minimum thickness of 1/4-inch after machining.
- H. Provide a gasket or mastic to seal between the gate frame and the wall thimble.
- I. For mounting to existing cast iron and ductile iron thimbles provide new slide gates suitable for bolting to existing thimbles. Contractor to verify thimble dimensions and bolting pattern and submit with shop drawings.
 1. Clean existing thimbles and provide 1/4-inch thick elastomeric gasket.

2.07 MANUAL OPERATORS

- A. Provide a manual gate operator for each gate so specified.

1. Provide all gates with slides 24 inches tall or taller with a gearbox operator suitable for use with a portable operator.
- B. Type of operator as indicated on the Contract Drawings.
- C. Manually operated floorstands and benchstands:
1. Handwheel or crank operated floorstand or benchstand as indicated on the Contract Drawings.
 - a. Handwheel: No gear reduction.
 - b. Handwheel or Crank Gearbox Operator: Single or double gear reduction.
 - c. Material: Cast ductile iron housing
 2. Provide a threaded cast bronze lift nut to engage operating stem.
 3. Provide roller bearings above and below a flange on the operating nut to support both opening and closing thrusts.
 4. Operate gates under the operating head and design head, as specified and indicated, with no greater than a 40 pound effort on the crank or handwheel.
 5. Gears, where required, steel with machined cut teeth designed for smooth operation.
 6. Provide Type 304 or 400 Series stainless steel pinion shafts on crank operated benchstands and floorstands supported on tapered roller bearing or ball bearings with all components totally enclosed in a weatherproof housing with a removable cover.
 - a. Design bearing arrangement for use with portable operators specified herein.
 7. Provide mechanical seals on the operating nut and the pinion shafts to exclude moisture and dirt and prevent leakage of lubricant out of the hoist mechanism.
 8. Provide lubricating fittings for the lubrication of all gears and bearings.
 9. Floorstands: Provide a Type 316L stainless steel pedestal, constructed of minimum Schedule 40 tube and 3/8-inch thick base plates, designed to position the input shaft or crank operator or handwheel approximately 36-inch above the operating level.
 10. Benchstands: Provide with a rectangular cast ductile iron base machined and drilled for mounting purposes. Provide all adaptor plates of Type 316L stainless steel.
 11. Permanently attach or cast an arrow with the word "OPEN" on the floorstand, benchstand or handwheel indicating the direction of rotation to open the gate.
 12. Handwheels: Minimum 15 inches, maximum 24 inches diameter and removable.

13. Cranks: Cast aluminum or stainless steel with revolving nylon grip and removable.
14. Provide two gearboxes for all upward opening gates 60 inch wide and larger and with opening widths greater than 2 x gate height. Provide two gearboxes for all downward-opening gates wider than 48 inch wide and larger and with opening widths greater than 2 x gate height.
 - a. Provide Type 316 stainless steel interconnecting shaft.
 - b. Provide flexible couplings at each end of the interconnecting shaft.
 - c. Provide a handwheel or crank mounted on the pinion shaft of one of the gear boxes.
 - d. Interconnecting shaft shall have stainless steel or aluminum shroud to cover the shaft driven by electric motor operator.

D. Extended Operators

1. Provide an extended operator system to bring the pinion shaft to 36 inches above the operating level utilizing chain and sprockets when the centerline of the handwheel on a non-gear operator is located 48 inches or more above the operating level.
2. Chainwheels are not acceptable.
3. Provide a removable Type 316L stainless steel cover to enclose the chain and sprockets.
4. If the centerline of the pinion shaft is 60 inches or less above the operating level a handwheel may be used with a gearbox in lieu of the extended operator system specified above.

E. Operating Nut

1. When indicated or specified provide 2 inch square operating nut and with a non-rising stem.
 - a. Nut Material: Bronze.
 - b. Where indicated and specified provide a Type 316L stainless steel or cast-iron floor box be set in the concrete floor above the gate as indicated.
 - c. Provide one Type 316L stainless steel T-handle wrench for operation.

F. Floorstands and Wall Brackets

1. Provide Type 316L stainless steel floorstands of a height such that the handwheel or crank operated pinion shaft is located 36 inches above the operating level.

2. Provide Type 316L stainless steel wall brackets to support floorstands.
 - a. Provide wall brackets reinforced to withstand in compression a minimum of 2 x rated output of the operator with an 80-pound effort on the crank or handwheel.

2.08 ELECTRIC MOTOR ACTUATORS

- A. Provide in accordance with Section 40 23 13.03.

2.09 SHOP PAINTING

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces; high solids epoxy in accordance with Section 09 96 00.
- B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

2.10 SHOP TESTING

- A. Comply with the requirements specified in Section 01 75 13 and as specified herein.
- B. Provide motor shop testing in accordance with Section 26 20 10.
- C. Assemble each gate and inspect for proper seating.
 1. Check clearance between frame and disc seating surfaces.
- D. Fully open and close each gate in guide system to ensure gates operate freely as recommended by the gate manufacturer.
- E. Conduct a shop leakage test at the design unseating head on each gate to confirm leakage as specified and indicated for Field Testing.
- F. Operate floorstands and benchstands to insure proper assembly and operation.
- G. Repeat tests until specified results are obtained.
- H. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install items in accordance with shop drawings, manufacturer's printed instructions and as indicated.
- B. Clean debris, dirt, and gravel, from inside of gates and channels before placing gates.
- C. Install slide gates in completely assembled condition.
- D. Erect and support slide gates in positions free from distortion and strain on appurtenances during handling and installation.
- E. Inspect material for defects in workmanship and material.
- F. Clean out debris and foreign material from gate opening and seats, test operating mechanisms to check proper functioning, and check nuts and bolts for tightness. Repair gates and other equipment which do not operate easily or are otherwise defective.
- G. Set floorstand operators and stem guides so stems run smoothly in true alignment. Anchor guides firmly to walls. Check distances from centerlines of gates to operating level or base of floorstand and adjust if necessary to suit actual conditions of installation.

3.02 FIELD TESTING

- A. Comply with the requirements specified in Section 01 75 13 and as specified herein.
- B. Field testing will not be conducted without a procedure accepted by the Engineer calibration certificates for all testing equipment, gauges and flow meters and a completed and signed pretesting check list. See Division 1 for checklist.
- C. After installation of gates, and after inspection, operation, testing and adjustment have been completed by the manufacturer's field service technician, conduct operating and leakage test for each gate in presence of the Engineer to determine its ability to operate as specified, and to operate smoothly without jamming under specified conditions.
- D. Test all operators.
- E. Leakage Test: Leakage not to exceed 0.05 gpm per foot of seal perimeter.
 - 1. Conduct tests at design heads of unseating/seating heads as follows:
 - a. SDG-0401-1C and SDG-0402-1C: 25 feet/25 feet
 - b. SDG-0102-1A and SDG-0102-1B: 10 feet/10 feet
- F. Immediately correct or replace all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

- G. Repeat tests until specified results are obtained.
- H. Contractor to provide all water labor, piping, testing equipment for conducting tests.
- I. Make all adjustments necessary to place equipment in specified working order at time of above tests.
- J. Remove and replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the satisfaction of the Engineer that equipment will perform the service specified, indicated and as submitted.

3.03 FIELD TOUCH-UP PAINTING

- A. After installation and testing accepted by the Engineer, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 13.01

PROCESS VALVES AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and process valves and appurtenances as indicated and in compliance with Contract Documents.
 - 1. Provide sizes and capacities as indicated or specified.
- B. Where 2 or more valves or equipment of the same type and size are required, the valves shall be furnished by the same manufacturer.
- C. Contractor shall verify that flanges on pipe match the bolt hole pattern of the flanges on the valves and mechanical appurtenances.
- D. All appurtenances shall be NSF 61 certified if used in potable water systems.
- E. Unless noted otherwise below or on the Contract Drawings, all system components shall be rated for the maximum system pressure or higher.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.20.7: Hose Coupling Screw Threads.
 - 2. B16.1: Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125 lb.
 - 3. B16.4: Cast-Iron Threaded Fittings, Class 125 and 250.
 - 4. B16.10: Face-to-Face and End-to-End Dimensions of Ferrous Valves.
- B. ASTM International (ASTM):
 - 1. A48: Standard Specification for Gray Iron Castings.
 - 2. A126: Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
 - 3. A536: Standard Specification for Ductile Iron Castings.
- C. American Water Works Association (AWWA):
 - 1. C500: Metal-Seated Gate Valves for Water Supply Service.

2. C504: Rubber-Seated Butterfly Valves.
3. C509: Standard Specifications for Resilient-Seated Gate Valves for Water and Sewage Systems.
4. C515: Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
5. D102: Coating Steel Water-Storage Tanks.

D. NSF International (NSF):

1. 61: Drinking water system components Health effects

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00:

1. Data regarding valve characteristics and performance including Cv.
2. Shop drawing data for accessory items.
3. Manufacturer's literature as needed to supplement certified data.
4. Operating and maintenance instructions and parts lists.
5. Listing of reference installations as specified with contact names and telephone numbers.
6. Valve shop test results.
7. Qualifications of field service technician.
8. Shop and Field inspections reports.
9. List of recommended spare parts other than those specified.
10. Recommendations for short-term and long-term storage.
11. Special tools.
12. Shop and field testing procedures and equipment to be used.
13. Number of service technician days provided and per diem field service rate.
14. Manufacturer's product data and specifications for shop painting.
15. Provide a layout drawing, plan and section showing orientation of plug, gate, check, ball valves and actuators and nearest obstructions for each valve.
16. Manufacturer's product data and specifications for shop painting.

17. Provide a listing of the materials recommended for each service specified and indicated. Provide documentation showing compatibility with process fluid and service specified and indicated.
 18. The latest ISO 9001 series certification or quality system plan.
 19. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
 - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
- B. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations and clarifications from the specified requirements.
1. If deviations and clarifications from the specifications are indicated, and are therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 2. Failure to include a copy of the marked-up specification sections and/or the detailed justifications for any requested deviation or clarification will result in submittal return without review until a marked-up specification and justification are resubmitted with the entire package.

1.04 SPARE PARTS:

- A. Comply with requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Provide enclosures for the area classifications specified and indicated.
- C. Contractor is responsible for verifying outside diameter of pipe to be tapped.
- D. Services of Manufacturer's Representative as stated in Section 01 43 00 and specified herein.

- E. Manufacturer of valve shall have a minimum of five (5) operating installations with valves of the size specified and in the same service as specified operating for not less than five (5) years.
- F. If equipment proposed is heavier, taller, different laying length or requires more operating space than specified and indicated, provide all structural, architectural, mechanical, electrical, and plumbing revisions at no additional cost to the Owner.
 - 1. If equipment is heavier than specified, the Contractor shall provide all hoisting equipment sized to maintain the minimum safety factor between the specified maximum equipment weight and the lifting capacity of the hoisting equipment indicated and specified.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10 and as specified herein.

PART 2 - PRODUCTS

2.01 RESILIENT SEAT GATE VALVES 12-INCH AND SMALLER:

A. Resilient Seat Gate Valves:

- 1. Manufacturers, or approved equal of NRS Type Valves:
 - a. J&S Valve
 - b. Kennedy Valve
 - c. American Flow Control
 - d. Mueller Company

B. General:

- 1. Provide valves that conform to NSF Standard 61.
- 2. Non-potable water service: Provide resilient seat gate valves for all sizes indicated. If resilient seat valves are not available provide solid wedge gate valves.
- 3. Potable water service: Provide resilient seat gate valves for all sizes indicated.
- 4. Provide resilient seated valves conforming to AWWA C509 or AWWA C515 except as modified herein.

C. Materials:

- 1. Body and Bonnet: ASTM A536 ductile iron.
- 2. Wedge: ASTM A536 ductile iron encapsulated with EPDM.

3. Provide all other materials as specified in AWWA C509 or C515. Working water pressure:

Pressure Rating	
inch	psi
3 to 16	250
18 & Larger	150

4. Exposed Valves: Flanged NRS valves with handwheel. Face-to-face dimensions to comply with ANSI B16.10, flanges to comply with ANSI B16.1.
5. Buried Valves: Mechanical joint ends, non-rising stem valves with operating nut in lieu of hand wheel. Provide gate boxes, steel extension stems or universal-joint operating rods with 2-in square operating nuts at upper end with coupling connected to valve stem to bring to operating nut to within 6 inches of ground surface.
6. Provide counterclockwise rotation to open valves.
7. Provide handwheels with arrow and word "open" to indicate open direction.
8. Provide geared operators where indicated. Gearing shall be steel with enclosed cases.
- Provide spur gears for buried valves with stems vertical
 - Provide bevel gears where required by position of valve.
 - Provide buried valves with totally enclosed gear cases to enclose both the gears and valve stuffing box and provide gasketed Type 316 stainless steel removable cover plates with Type 316 stainless steel fasteners to allow access to the stuffing box.
9. Chainwheels: Provide where required as specified herein. Provide beveled gear operator to mount chainwheel in vertical position. Provide valve mounted so that the arrow indicator will be visible from the floor level.
10. Provide conventional packing or double O rings in non-rising stem valves.
11. Valves capable of being repacked or O ring replaceable while under pressure.
12. Provide Type 316 stainless steel bolts and bronze nuts for stuffing box follower.
- D. Provide all gate valves with all internal and external wetted parts coated with a fusion bonded epoxy in accordance with ANSI/AWWA C550.

2.02 ECCENTRIC PLUG VALVES:

A. Manufacturers:

- DeZurik.

2. Val-Matic.
- B. Type: Non-lubricated, eccentric.
- C. Body Working Pressure:
1. Cast Iron, ASTM A126 Class B or Ductile Iron, ASTM A536, Grade 64-45-12.
 - a. Valves 4-inch through 12-inch: 175 psi.
 - b. Valves 14-inch and larger: 150 psi.
- D. Ends:
1. Grooved: ANSI/AWWA C606 for ductile iron valves.
 2. Flanged: ANSI B16.1 Class 125 pound for cast iron valves.
 3. Buried Valves: Mechanical joint.
- E. Valve Ports:
1. Provide rectangular ported valves only, circular ports are not acceptable.
 2. All valves 100% port area, reduced port valves are not acceptable.
- F. Valve Seats:
1. Coat plug with seat material specified. Bolted systems are not acceptable.
 - a. Seat Material:
 - (1) Neoprene or Buna-N synthetic rubber.
 2. Provide valves with one piece coated plugs with mating seats of 90 percent, minimum, pure nickel 1/8-inch welded into the body of valves.
 3. Provide valves with seats clamped to valve with mating seat of 90 percent, minimum, pure nickel welded to the valve body.
- G. Upper and Lower Plug Journal Bearings:
1. Removable, permanently lubricated stainless steel bushings for valves 20-inch and smaller.
 2. Bronze bearings with Type 316 stainless steel bushings for valves 24-inch and larger.
 3. Provide grit seals for upper and lower plug shafts for all valves.

H. Stem Seals:

1. Adjustable multiple V-packing.
2. Replaceable and adjustable without valve disassembly.
3. Provide valves with two sets of packing rated for vacuum service for all pump suction isolation service and for services where a vacuum is specified and indicated.

I. Operators for Valves 4-inch and larger:

1. Manual Operators:

- a. Gear operated with handwheels, levers are not acceptable.
 - b. Provide gear operators rated for bi-directional shutoff at the valve working pressure rating as specified herein.
 - c. Gear operators: Totally enclosed worm gear, traveling nut type is not acceptable. Provide permanent lubrication, watertight and dustproof, with adjustable open and closed stops and plug position indicator.
 - d. Provide all work gears designed and certified to withstand input loads up to 300-foot-pounds minimum at the stops without damage.
 - e. Chainwheels: Provide where required as specified herein.
 - f. Where indicated provide Type 316 stainless steel stem extension to operating floor elevation as shown and provide the bevel gear operator with a fabricated steel floorstand and handwheel.
2. Electric Motor Actuators: Provide where indicated and provide in accordance with Section 40 23 13.03.

J. Shop Testing:

1. Provide all plug valves tested and certified bubble tight in both directions at the full rated working pressure as specified herein.

K. Shop Painting:

1. Provide epoxy painting as specified herein.

2.03 BUTTERFLY VALVES – LIQUID SERVICE (AWWA):

A. Manufacturers or approved equal:

1. American AVK

2. DeZurik
 3. Val-Matic
- B. Provide valves that conform to NSF Standard 61.
- C. Provide valves conforming to AWWA Standard C504 for Rubber Seated Butterfly Valves except as modified herein.
- D. Valves utilizing: Continuous rubber lining on the internal body surfaces and extending over the flanges, or a disk which sits at an angle to the axis of the pipe are acceptable.
- E. Valve Bearings: Self-lubricating, nonmetallic material to effectively isolate the disc-shaft assembly from the valve body. Cast or ductile iron thrust or journal bearing surfaces are NOT acceptable.
- F. Class 150B valves except as specified or indicated.
- G. Valve Body: ASTM A126 Class B cast iron or ductile iron.
1. Exposed or submerged service: Flanged short body valve.
 2. Buried service: Mechanical joint body.
 3. Wafer, lug wafer or tapped wafer valves may be used only as specified or indicated.
- H. Valve Seats:
1. Potable Water Service: Molded new natural rubber or synthetic rubber.
 2. Wastewater or Sludge Service: Molded neoprene, Buna-N or other synthetic elastomer resistant to oil and grease.
 3. Provide seat mounted on disc or in body.
 4. Provide seats offset from shaft and field replaceable for all valves 24-inch and larger.
 5. Provide seats mounted on disc, mechanically fastened to disc with Type 316 stainless steel hex head screws. Provide rubber seat reinforced with stainless steel retaining ring. Seats vulcanized or bonded to the disc are not acceptable.
- I. For valves with seats mounted on body provide the seats clamped or mechanically secured with Type 316 stainless steel fasteners.
- J. Mating surfaces for valve with seat in body: Type 316 stainless steel or plasma applied nickel-chromium material containing 80 percent nickel, 20 percent chrome.
- K. Plated or sprayed on mating surface material not acceptable.

L. Seat Placement:

1. If seat on disc provide disc of ASTM A126 Class B cast iron or ductile iron.
2. If seat in body, provide disc of ASTM A126 Class B cast iron, ductile iron or Type 316 stainless steel. Type 316 Stainless steel edge on cast or ductile-iron discs secured with Type 316 stainless steel threaded fasteners, heat shrunk on disc, a welded-on overlay, or a plasma applied nickel-chrome material.

M. Shaft: Type 316 stainless steel. Either one piece extending completely through disc or stub shafts inserted into valve disc stubs.

N. Shaft seal of the split-V type or O-ring type. Seal replaceable without disassembly of valve.

O. Manual Operators:

1. Operator capable of valve operation at rated pressure with a maximum 80 lb. pull on actuator. Operator to be self-locking.
2. Valves 8-inch and smaller, provide lever operator, 18-inch maximum length.
3. Valves 10-inch and larger, or where chain wheels are required, provide traveling nut operator. Provide position indicator.
4. Chainwheels: Provide where required as specified herein.

P. Buried or submerged valves: Provide gear operator with operating nut and valve box or handwheel operated floorstand as shown. Gear operator to be totally enclosed with gasketed Type 316 stainless steel covers with Type 316 stainless steel fasteners for access to valve packing.

Q. Electric Motor Operator: Provide in accordance with Section 40 23 13.03.

2.04 DOUBLE OFFSET BUTTERFLY VALVES – LIQUID SERVICE (AWWA):

A. Manufacturers or approved equal:

1. Av-Tek
2. VAG
3. American AVK

B. Double Offset Butterfly valves shall have a double offset disc design whereby the centerline of the disc is horizontally and vertically offset from the body seat and where the elastomeric seat release compression only after a few degrees of the opening to reduce torque and seat wear, also known as a double eccentric type. Valves shall be designed, manufacturer and tested in accordance with AWWA C504, except as modified herein.

- C. Double Offset Butterfly valves shall be rated for working pressures of no less than 250 psi and shall provide zero leakage at full rated pressure on both sides of the disc.
- D. Provide valves that conform to NSF Standard 61 and NSF 372. Valves to be submerged within Clearwell tanks shall be NSF 61 certified for submerged conditions.
- E. Disc body shall conform to ASTM A536 65-45-12 or 60-40-18 and shall be pinned used 2205 Duplex stainless steel pin. Disc seat shall be EPDM (for use with ozonated water) and shall be secured to the disc with Type 316 stainless steel hardware. Disc seat shall be EPDM for use with ozonated water. The disc shall be a flow through design to reduce head loss.
- F. Body seat shall be 316L stainless steel and shall be applied through a high alloy weld double overlay process with a minimum thickness of 5 mm.
- G. Valve Stems shall be Type 431 stainless steel for Class 150B and 17-4 PH stainless steel for Class 250 valves. Valve stems shall be dry stem design with O-rings.
- H. In submerged conditions:
 - 1. Extensions stems shall be comprised of 1-1/4" Sch40 Type 316 stainless steel pipe and shall be equipped with universal joints.
 - 2. Couplers shall be Type 316 stainless steel.
 - 3. Gearboxes shall be packed with food grade grease.
- I. The valves shall have a heavy-duty ductile iron body conforming to ASTM A 536 65-45-12. Maximum flow velocity shall be less than 16 fps for cold water service.
- J. Valve End Connections:
 - 1. Exposed or submerged service: Flanged fully faced and drilled per ANSI B16.1 Class 150B
 - 2. Buried service: Mechanical joint.
- K. Valve Seats:
 - 1. Potable Water Service: EPDM.
 - 2. The rubber seat shall be clamped or mechanically secured in the valve disc with a continuous Type 316 stainless steel ring with Type 316 stainless steel fasteners. The rubber seat shall be a continuous uninterrupted sealing surface.
 - 3. Resilient seats shall be field replaceable without the use of special tools or epoxy.
- L. The resilient seat mating surface shall be a continuous uninterrupted Type 316 stainless steel ring mounted in the valve body.

M. Plated or sprayed on mating surface material not acceptable.

N. Bearings:

1. The bearings shall be corrosion resistant, self-lubricating sleeve type, made from bronze or PTFE impregnated copper with steel backing.
2. Thrust bearings shall be provided and shall be adjustable

O. The valve disc shall be rigidly connected to the stem by two pins for each shaft plus one backup safety key. The pins shall be protected for water and corrosion by O-ring seals.

P. All bolting and hardware shall be stainless steel AISI grade 316.

Q. Shaft: Type 316 or 2205 duplex stainless steel. Either one piece extending completely through disc or stub shafts inserted into valve disc stubs.

R. Shaft seal of the split-V type or O-ring type. Seal replaceable without disassembly of valve.

S. Manual Operators:

1. Operator capable of valve operation at rated pressure with a maximum 80 lb pull on actuator. Operator to be self-locking.
2. Valves 8-inch and smaller, provide lever operator, 18-inch maximum length.
3. Valves 10-inch and larger, or where chain wheels are required, provide traveling nut operator with handwheel. Provide position indicator.
4. Chainwheels: Provide where required as specified herein.

T. The valve shall have a fusion bonded epoxy protective coating inside and outside with a minimum DFT of no less than 14 mils. Coating shall meet AWWA C550 and shall be non-toxic and impart no taste to water. There shall be no exposed, uncoated iron in the interior or exterior of the valve.

U. Buried or submerged valves: Provide gear operator with operating nut and valve box or handwheel operated floorstand as shown. Gear operator to be totally enclosed with gasketed Type 316 stainless steel covers with Type 316 stainless steel fasteners for access to valve packing.

V. Electric Motor Operator: Where shown on the Contract Drawings provide electric motor operator in accordance with Section 40 23 13.03.

2.05 BUTTERFLY VALVES - CHEMICAL SERVICE-LINED:

A. Manufacturers:

1. American

2. DeZurik

B. Materials:

1. Body: Ductile Iron ASTM A395

2. Stem: Type 316L stainless steel

3. Liner: Virgin PTFE

4. Elastomer: Hypalon

C. Working Pressure: 150 psi

D. Body Style: Lug, 150 pound (Class 150)

E. Provide sealing system using belleville springs

F. Operator:

1. 6-inch and smaller: Lever handle, locking type

2. 8-inch and larger: Gear with handwheel

3. Electric: Provide in accordance with Section 40 23 13.03.

2.06 BALL VALVES – GENERAL SERVICE:

A. Manufacturers:

1. Jamesbury

2. KF

3. Inline

4. Kitz

5. FNW

6. Watts

7. Apollo

8. NIBCO

B. Valves 1/2-inch through 4-inch

1. Materials:

- a. Body and End Cap: Three piece, ASTM A351 Grade CF8M.
 - b. Body Seal: PTFE.
 - c. Seat: RTFE.
 - d. Ball: Type 316 stainless steel.
 - e. Stem: Type 316 stainless steel.
 - 2. Pressure Rating:
 - a. 1/2-inch through 2-inch: 1000 psi at 100 degrees F
 - b. 2-1/2-inch through 4-inch: 800 psi at 100 degrees F
 - 3. Ends:
 - a. 2-inch and Smaller: Screwed or flanged.
 - b. 3-inch and larger: Flanged.
- C. Valves 4-inch through 12-inch.
- 1. Materials:
 - a. Body and Adaptor: Two piece, ASTM A351 Grade CF8M.
 - b. Seat: TFE.
 - c. Ball: Type 316 stainless steel.
 - d. Stem: Type 316 stainless steel.
 - 2. Pressure Rating: ANSI Class 150.
 - 3. Ends: Flanged.
- D. Actuators:
- 1. Manual:
 - a. 4-inch and Smaller: Lever.
 - b. 6-inch and Larger: Gear operator.
 - c. Provide chainwheels where required as specified herein.
 - 2. Electric Motor Actuators: Provide in accordance with Section 40 23 13.03.

2.07 BALL VALVES,COPPER-ALLOY – GENERAL SERVICE:

A. Manufacturers:

1. Kitz
2. FNW
3. Watts
4. Apollo
5. NIBCO

B. Valves 1/2-inch through 4-inch

1. Materials:

- a. Body and End Cap: “Lead-free” copper alloys including bronze and brass
- b. Seat: PTFE
- c. Ball: “Lead-free” copper alloys including bronze and brass
- d. Stem: “Lead-free” copper alloys including bronze and brass
- e. NSF 61 and NSF 372 certified

2. Pressure Rating:

- a. 1/2-inch through 2-inch: 600 psi cold working pressure
- b. 2-1/2-inch through 4-inch: 400 psi cold working pressure

3. Ends:

- a. 4” and Smaller: Threaded or flanged.

C. Actuators:

1. Manual:

- a. 4-inch and Smaller: Lever

2.08 BALL VALVES - NON-METALLIC:

A. Manufacturers:

1. Spears

2. ASAHI
3. NIBCO/Chemtrol
4. Hayward

B. Materials:

1. Body: Material as specified or indicated.
 - a. PVC: ASTM D-1784, Type 1, Grade 1, Class 12454B.
 - b. CPVC: ASTM D-1784, Type 4, Grade 1 with hydrostatic designs stress of 1600 psi at 73.4 degrees F.
 - c. Polypropylene: ASTM D-2146, Type 1 with tensile strength of 4977 psi at 77 degrees F.
 - d. PVDF: Minimum tensile strength of 5000 to 7000 psi at 77 degrees F.
2. Ball: Same material as valve body.
3. Seats: Teflon, concave design to absorb expansion.
 - a. Triangular seat design is not acceptable.
 - b. Provide viton or EPDM back up cushions to absorb expansion.
4. Seals: Viton, all Viton shall contain a minimum of 55 percent Viton.
5. Provide vented ball valves for sodium hypochlorite and caustic services.

C. Ends: Type as specified or indicated:

1. Provide ends flanged in accordance with ANSI B16.1 Class 150 lb. standard drilling.
2. True union design with integral union nuts on both ends of valve.
 - a. Threads between union nuts and valve body: Provide Buttress threads to protect against pipeline expansion and water hammer stresses.

D. Machine the following to final tolerances:

1. Exterior of ball
2. Interior of socket and threaded connections
3. Teflon seat recesses

4. Stem
 5. Neck I.D.
 6. Both end connectors
 7. Both carriers
- E. Valve Port:
1. 2-inch and smaller valves: full port.
 2. 3-inch and 4-inch valves: maximum of one pipe size reduction.
 3. 6-inch valves: Venturi design.
- F. Valve Ratings:
1. PVC: 150 psi at 120 degrees F.
 2. CPVC: 85 psi at 175 degrees F.
 3. Polypropylene: 85 psi at 175 degrees F.
 4. PVDF: 85 psi at 210 degrees F.
 5. All valves rated for 29.92 inch mercury vacuum.
- G. Physical Properties:
1. Tensile stress, psi; per ASTM D638 Test Method:
 - a. PVC: 7800
 - b. CPVC: 9200
 - c. PP: 5000
 - d. PVDF: 7800
 2. Flexural Stress, psi; per ASTM D790 Test Method:
 - a. PVC: 15650
 - b. CPVC: 17060
 - c. PP: 9240
 - d. PVDF: 14930

3. Compressive Strength, psi; per ASTM D695 Test Method:
 - a. PVC: 14220
 - b. CPVC: 15650
 - c. PP: 9950
 - d. PVDF: 14220
4. Hardness, Rockwell R, per ASTM D785 Test Method:
 - a. PVC: 115
 - b. CPVC: 118
 - c. PP: 95
 - d. PVDF: 110
5. Water Absorption, percent, 24 hr., 1/8-inch thickness, per ASTM D570 Test Method:
 - a. PVC: 0.07 percent
 - b. CPVC: 0.15 percent
 - c. PP: 0.01 percent
 - d. PVDF: 0.03 percent

H. Operators:

1. Lever, with retaining screw.
2. Electric Motor Actuators:
 - a. Provide 120V single phase actuators in accordance with Section 40 23 13.03.
 - b. Enclosure:
 - (1) NEMA 7 explosion proof for classified areas
 - (2) NEMA 4 or 4X for non-classified areas.

2.09 BALL VALVES – CHEMICAL SERVICE-LINED:

A. Manufacturers:

1. Technova

2. Richter
3. Flowserve

B. Valves 4-inch through 12-inch:

1. Materials:
 - a. Body and Adaptor: Two piece, ASTM A395 ductile iron PFA lined
 - b. Seat Rings: PTFE
 - c. Ball and Stem:
 - (1) 1/2-inch through 2-inch: Type 316 stainless steel PFA lined.
 - (2) 3-inch through 6-inch: Type 316 stainless steel stem and integral steel ball PFA lined.
2. Pressure Rating: 200 psi.
3. Ends: Flanged

C. Actuators:

1. Manual: Provide level operator
 - a. Provide chainwheels where required as specified herein.
2. Electric Motor Actuators: Provide in accordance with Section 40 23 13.03.

2.10 SWING CHECK VALVES – 3-INCH AND LARGER:

A. Valves 3-inch and larger:

1. Manufacturers:
 - a. Golden Anderson
 - b. APCO
 - c. Val-Matic
2. Working pressure:

Size	Pressure
3 to 12-inch	175 psi
14-inch and larger	150 psi

3. Valve Body:
 - a. ASTM A126 Class B cast iron with integral flanges, faced and drilled per ANSI B16.1 Class 125.
 - b. Provide full waterway type body with a net flow area not less than the nominal inlet pipe size when swung open a maximum of 25 degrees. When closed, the valve shall seat drop tight.
 - c. Provide a replaceable Type 316 stainless steel body seat.
4. Valve Disc:
 - a. ASTM A126 Class B cast iron. Provide disc faced with a renewable resilient seat ring of a material suitable for the service specified and indicated. Provide Type 316 stainless follower ring and hardware.
5. Disc Arm:
 - a. Ductile iron or steel, suspended from and keyed to an austenitic stainless steel shaft located entirely above the waterway and supported at each end by bronze bushings.
 - b. Provide shaft to rotate freely without the need for external lubrication.
 - c. Provide the shaft sealed where it passes through the body by a stuffing box and adjustable packing. O-ring type shaft seals are not acceptable.
 - d. Provide valves with an outside lever and adjustable counterweight to initiate valve closure. Provide final closure dampened by means of a single, side-mounted bronze air-cushion assembly directly mounted to the valve body on machined pads.
 - e. Provide an adjustable amount of cushioning without the need for pre-charged air chambers. Commercial air cylinders which pivot and/or are attached with fabricated brackets are not acceptable.
6. If indicated on Contract Documents, provide an adjustable limit switch to indicate when the valve is closed. Provide one normally open and one normally closed contact. Enclosure: NEMA 6P for all non-hazardous area and NEMA 7 for hazardous areas.

2.11 SWING CHECK VALVES – 3-INCH AND SMALLER:

- A. Valves 1/2-inch to 2-inch:
 1. Working Pressure: 200 psi
 2. Type: Y-Pattern
 3. Ends: Threaded ASME 1.20.1

4. Materials:
 - a. Body, Cap Disc and Hinge Arm: ASTM A351 CF8M
 - b. Hinge Pin, Disc Nut Disc Washer and Plug: ASTM A276 Type 316 stainless steel
 - c. Seal and Gaskets: PTFE

B. Valves 1/2-inch to 3-inch:

1. Working Pressure: ANSI Class 150
2. Type: Swing check with bolted cover
3. Ends:
 - a. 1/2-inch through 2-inch: Threaded ASME 1.20.1
 - b. 1/2-inch thru 3-inch: Flanged
4. Materials:
 - a. Body, Cap Disc and Hinge Arm: ASTM A351 CF8M
 - b. Hinge Pin and Plug: ASTM A276 Type 316 stainless steel
 - c. Plug Seals and Gaskets: PTFE

2.12 GLOBE VALVES

A. Manufacturer

1. Apollo
2. VAG GA
3. Equal

B. Valves 2-inch and smaller:

1. Working Pressure: 200 psi.
2. Rising stem with plug type disc.
3. Ends: Threaded ASME 1.20.1.
4. Materials:
 - a. Body and Bonnet: ASTM A351 CF8M.

- b. Disc, Stem and Gland: ASTM A276 Type 316 stainless steel.
- c. Packing and Gaskets: PTFE.
- d. Handwheel: ASTM A536.

C. Valves 2-1/2-inch to 3-inch:

- 1. Working Pressure: ANSI Class 150.
- 2. OS&Y, bolted bonnet, solid or flexible wedge disc type.
- 3. Ends: Flanged ANSI B16.5.
- 4. Materials:
 - a. Body, Bonnet, Gland Flange and Disc: ASTM A351 CF8M.
 - b. Stem and Disc Nut: ASTM A276 Type 316 stainless steel.
 - c. Gland: ASTM A276 Type 304 stainless steel.
 - d. Packing and Gaskets: PTFE.

D. Valves larger than 3-inch

- 1. Working pressure: ANSI Class 150
- 2. Full port
- 3. Ends: Flanged ANSI B16.5
- 4. Materials
 - a. Body and disc material: Cast iron ASTM A-126
 - b. Seat ring and seal ring material: Cast Bronze ASTM B-62
 - c. Guide spindle, stem, and packing gland material: Brass ASTM B-16
 - d. Check screw, disc cover, stud, nut, and bonnet material: Carbon Steel ASTM A-307B.

2.13 SOLENOID VALVES:

A. Manufacturers:

- 1. JD Gould.
- 2. ASCO.

3. Berkert.

B. Type:

1. Size: 1/8-inch to 2-inch.
2. Globe type.
3. 2-way, internal piston pilot operated.
4. Energize to open.
5. Operating Pressure Differential: 150 psi.

C. Materials:

1. Body: Type 316 stainless steel.
2. Seat Discs: PTFE.
3. Piston Assembly: Type 316 stainless steel.
4. Pilot Assembly: Type 316 stainless steel jacket welded on steel core.

D. Coil: Class F.

E. Electrical: 120 Volt, 1 phase, 60 Hertz.

F. Ends: Threaded.

G. Enclosure: NEMA 4X for locations in non-classified areas and NEMA 7 for use in classified areas.

2.14 SOLENOID VALVES – COPPER ALLOY:

A. Manufacturers:

1. ASCO.
2. AGB Industries.
3. ODE.

B. Type:

1. Size: 1/8-inch to 2-inch.
2. Guided pilot diaphragm
3. 2-way, internal piston pilot operated.

4. Energize to open or close, as shown on Contract Documents.
5. Operating Pressure Differential: 150 psi.

C. Materials:

1. Body: Lead Free Brass
2. Seat Discs: FPM
3. Piston Assembly: Type 316 stainless steel.
4. Pilot Assembly: Type 316 stainless steel jacket welded on steel core.

D. Coil: Class F.

E. Electrical: 120 Volt, 1 phase, 60 Hertz.

F. Ends: Threaded.

G. Enclosure: NEMA 4X for locations in non-classified areas and NEMA 7 for use in classified areas.

2.15 SOLENOID VALVES – NON METALLIC:

A. Manufacturers:

1. Hayward Industrial products.

B. Type:

1. Size: 1/4-inch to 1-inch.
2. Globe type.
3. 2-way.
4. Energize to open.
5. Operating Pressure Differential: 120 psi.

C. Materials:

1. Body: CPVC.
2. End Connectors: CPVC.
3. Seals and O-rings: EPDM.
4. Seal Cartridge: CPVC.

5. Union Nut and Bonnet Nut: CPVC.

D. Coil: Class F.

E. Electrical: 120 Volt, 1 phase, 60 Hertz.

F. Ends: True Union or Flanged as indicated.

G. Enclosure: NEMA 4X for locations in non-classified areas and NEMA 7 for use in classified areas.

2.16 INJECTION QUILLS – CHEMICAL SERVICE:

A. Type: Standard Service Retractable Injection Quill

B. General:

1. All materials of construction for injection quills shall be compatible with the service chemicals being injected.

C. Safety Rating: 150 PSI

D. Process Connection Size: 1-inch

E. Manufacturers:

1. SAF-T-FLO Water Services, Inc.
2. Engineer-Approved Equal

F. Provide assemblies consisting of the following components:

1. Type 316 stainless steel corporation stop with safety device to prevent release of solution tube under line pressure of Type 316 stainless steel ball valve.
2. Type 316 stainless steel flange tapped to accept the corporation stop or ball valve.
3. Solution tube of 1/3 diameter or greater of the pipe in which the chemical is injected into with a locking device to prevent release of the tube under line pressure.
 - a. Solution Tube Material:
 - (1) 10-inch or less: PVC
 - (2) 12-inch and greater: Alloy
 - b. Ball check valve as specified in Section 40 23 13.03.
 - c. Type 316 stainless steel chain.

4. Standard configuration injector tip.
5. Chemical line connection to the assembly:
 - a. Provide a section of polyethylene chemical tubing suitable for the service conditions in accordance with Section 40 23 19.05.
 - b. Isolation valve, PVC check valve, with an EPDM or FKM seal.

2.17 WATER PRESSURE REGULATORS:

A. Manufacturers:

1. Cascho
2. Watts

B. Provide water pressure regulators as specified and indicated.

1. Provide sizes and flow rates as specified and indicated.

C. Provide self-contained units operated by internal spring loaded diaphragms or pistons.

1. Provide regulators of spring-opposed bronze piston type where not available in diaphragm configuration.

D. Materials:

1. Body and spring chambers: Type 316 stainless steel.
2. Steel body seat: Type 316 Stainless.
3. Seat disk: Buna-N.
4. Diaphragms: Buna-N reinforced.

E. End Connection: NPT Female

F. Provide regulators constructed such that all repairs may be performed with valve in-line.

G. Provide regulators with top adjusting screw to set downstream pressure.

H. Provide regulators sized for required flows with inlet pressure and outlet pressure as indicated.

I. Pressure variation at outlet of greater than 15 psig at maximum required flows is not acceptable.

2.18 COMBINATION AIR VALVE (CAV)

A. Manufacturers:

1. DeZurik (APCO)
2. GA
3. Crispin
4. Val-Matic
5. Vent-O-Mat

B. Valves: Provide combination air/vacuum valve designed to allow large quantities of air to escape out of the orifice when filling a pipeline and to close watertight when the liquid enters the valve, and shall be equipped with a small air release orifice to allow small pockets of air to escape automatically and independently of the large orifice. The Air/Vacuum valve shall also permit large quantities of air to enter through the orifice when the pipeline is being drained to break the vacuum. The discharge orifice area shall be equal or greater than the inlet of the valve.

C. Provide valves manufactured and tested in accordance with AWWA C512.

D. The valve shall consist of a body, cover, baffle, float and seat. The baffle will be designed to protect the float from direct contact of the rushing air and water to prevent the float from closing prematurely. The seat shall be fastened into the valve cover without distortion and shall be easily removed, if necessary. The float shall be stainless steel and shall be center guided into the seat.

E. Provide low-durometer seats for low pressure applications where indicated on the Drawings.

F. End Connection: NPT Threaded

G. Materials of Construction

1. Body and Cover:
 - a. ASTM A126 Gr. B Cast Iron or ASTM A536 Gr 65-45-12 Ductile Iron.
2. Float
 - a. 304 Stainless Steel
3. Seat:
 - a. Buna-N

H. Rated Pressure: 175 psi

- I. Unless shown otherwise on the Drawings, all CAVs shall include a stainless-steel ball valve for isolation. Contractor shall field route drain piping for CAV to nearest floor or trench drain. Piping from host pipe to CAV shall be stainless steel. Pipe from CAV to drain shall be schedule 80 PVC.

2.19 BARREL TYPE COMBINATION AIR VALVE (BAV)

A. Manufacturers:

- 1. Vent-O-Mat Series RBX Model 1931 by RF Valves, Inc.
- 2. Proposed alternatives shall consider limited headroom in vaults.

- B. Combination air-vacuum valves shall have four functions of uninterrupted discharge of air/gas during filling, continuous discharge of dis-entrained pressurized air/gas, unrestricted vacuum break, and pipeline surge protection in a single chamber.

- C. Valves shall be anti-surge and anti-shock air release and vacuum break valves.

- D. Valves shall have studded wafer style inlet connection and t-outlet with bias flanged discharge outlet. Valve shall be rated for 276psi working pressure.

E. Materials for valve construction shall be as follows:

- 1. Floats: Solid HDPE with EPDM O-ring seals
- 2. Barrel: 304 Stainless Steel
- 3. Tie Rods and Fasteners: 304 Stainless Steel
- 4. Nozzle: 316 Stainless Steel
- 5. Flanges: Fusion bonded epoxy coated ductile iron

- F. Valve shall be NSF 61 certified. Valve shall have a 10 year in-service warranty for all internal components.

2.20 AIR RELEASE VALVES – CLEAN WATER SERVICE:

A. Manufacturers:

- 1. Val-Matic
- 2. APCO

- B. Valves: Provide air release valves of the automatic float operated type designed to release accumulated air from a piping system while the system is in operation and under pressure.

- C. Provide valves manufactured and tested in accordance with AWWA C512.

- D. Provide valves used in potable water service certified to ANSI/NSF 61 Drinking Water System Components - Health Effects.
- E. Valve manufacturer must have a quality management system that is certified to ISO 9001:2000 by an accredited, certifying body.
- F. Provide valves with the cover bolted to the valve body and sealed with a flat gasket.
- G. Provide replaceable resilient seats.
- H. Provide drop tight shut off to the full valve pressure rating.
- I. Provide floats guaranteed against failure including pressure surges.
- J. Mechanical linkage to provide sufficient mechanical advantage so that the valve will open under full operating pressure.
 - 1. Simple lever designs: Provide valves consisting of a single pivot arm and a resilient orifice button.
 - 2. Compound lever designs: Provide valves consisting of two levers and an adjustable threaded resilient orifice button.
- K. Provide valve body with threaded NPT inlets and outlets.
 - 1. Inlet Connection: Provide hexagonal for a wrench connection.
 - 2. Refer to Valve Schedule for working pressure requirements.
 - 3. Provide valves with two (2) additional NPT connections with ball valves as specified herein, one connection with a plug and one with a hose coupling for the gauges, testing, and draining.
 - 4. Provide a vacuum check on the outlet to prevent air from re-entering the system during negative pressure conditions.
- L. For valves in vaults, provide valves with an inflow preventer to prevent the introduction of contaminated water through the air valve outlet.
 - 1. Provide the inflow preventer to allow the admittance and exhausting of air while preventing contaminated water from entering during normal operating conditions.
 - a. Provide the inflow preventer flow tested by an independent testing lab approved by the American Society of Sanitary Engineers.
- M. Materials:
 - 1. Valve Body, Cover and Baffle:

- a. ASTM A126 Class B cast iron for working pressures up to 300 psig.
 - b. ASTM A536 Grade 65-45-12 Cast Ductile Iron for working pressures 300 psig and greater.
 - c. ASTM A216 Grade WCB cast steel.
 - d. ASTM A351 Grade CF8M stainless steel.
 - e. ASTM B584 Alloy C83600 cast bronze.
- 2. Floats, Orifice and linkage: Type 316 stainless steel, non-metallic components are not acceptable.
 - 3. Orifice Button: Viton for simple lever valves and Buna-N for compound lever designs.
 - 4. Hardware: Type 316 stainless steel.
 - 5. Screened Hood: Type 316 stainless steel.

N. Testing:

- 1. Test valves at 1.5 times the rated working pressure.

2.21 REDUCED PRESSURE ZONE ASSEMBLY

- A. Reduced Pressure Zone Assembly shall consist of a pressure differential relief valve located between two positive seating check valves assemblies and the entire assembly shall be NSF 61 listed and shall be lead free certified.
- B. Isolation valves shall not be supplied with this assembly but shall be as scheduled on the Drawings.
- C. Back siphonage protection shall include provision to admit air directly into the reduced pressure zone via a separate channel from the water discharge channel.
- D. Manufacturer:
 - 1. Series LF909 by Watts

2.22 CHAINWHEEL OPERATORS – STAINLESS STEEL

- A. Provide chainwheels with chain and chain guides. For all valves with handwheels or gear operators higher than 6.5 feet above operating floor level.
- B. Provide chain that reaches to within 3 feet of the operating floor level.
- C. For valves with gear operator mount with chainwheel in the vertical position.

D. Provide secondary safety restraint system.

E. Manufacturer:

1. Trumbull.

F. Materials:

1. Chainwheels: Pocket type wheel, Type 316 stainless steel.
2. Chain: Type 316 stainless steel straight link machine chain.
3. Hardware and Attachments: Type 316 stainless steel.
4. Safety Restraint Cables and Hardware: Type 316 stainless steel.

G. Materials:

1. Chainwheels: Sprocket type wheel, ductile iron.
2. Chain: Galvanized steel connecting link chain.
3. Hardware and Attachments: Galvanized steel.
4. Safety Restraint Cables and Hardware: Type 316 stainless steel.

2.23 FLOORSTANDS-NRS INDICATING TYPE:

A. Type: Non-Rising Stem (NRS), Indicating.

B. Materials:

1. Pedestal: Cast Type 316 stainless steel with a vertical indicating slot.
2. Indicator: Bronze. Provide indicator that travels on a threaded stem to indicate the position of the valve.
3. Handwheel: Type 316 stainless steel, 12-inch diameter.
4. Couplings: Type 316 stainless steel.

C. Provide the word “OPEN” cast in the pedestal at the top of the indicating slot and provide a “CLOSED” tag mounted to the pedestal, to indicate the closed position of the valve.

D. Floorstands fabricated by welding flanges to pipe are not acceptable.

2.24 EXTENSION STEMS:

A. Provide where indicated and required for operation of all valves

B. Material:

1. Stems: Type 316L solid stainless steel bar or Schedule 40 Type 316L pipe
 - a. Minimum Size: 1.25 inch diameter, Slenderness ratio <200
2. Connectors, thrust relief assemblies, torque tube assemblies, universal joints and operating nuts: Type 316 or Type 316L stainless steel
3. Miter gears: Cast iron with 2 part epoxy coating

2.25 FLOOR BOXES-CAST IRON

A. Manufacturer:

1. Trumbull Industries.

B. Provide floor boxes where indicated to provide support for extension stems for non-rising stem valves and a cover for the operating nut.

C. Floor Box Depth: 6 inches and capable of use in thicker floors with a 2 1/2 inch or 3 inch schedule 40 steel pipe nipple

D. Materials:

1. Body and Cover: Cast Iron ASTM A126
2. Bushing: Bronze, NSF 61
3. Hardware: Type 316 stainless steel

2.26 FLOOR BOXES-STAINLESS STEEL WITH PACKING

A. Manufacturer:

1. Trumbull Industries.

B. Provide floor boxes where indicated to provide support for extension stems for non-rising stem valves and a cover for the operating nut.

C. Floor Box Depth: 6 inches and capable of use in thicker floors with a 4 inch schedule 80 Type 316L stainless steel pipe nipple.

D. Provide system capable of a maximum 2 inch shaft extension.

E. Provide a water stop welded to the body

F. Provide cover with O-ring seal and six (6) stainless steel socket screws

G. Materials:

1. Body: 6 inch schedule 40 Type 316L stainless steel
2. Cover: Type 316L stainless steel
3. Packing Gland: Bronze, NSF 61
4. Packing: Viton A
5. Hardware: Type 316 stainless steel

H. Where indicated provide floor boxes with stuffing box with bronze, NSF61, glands, Type 316 stainless steel hardware and non-asbestos fiber packing

2.27 STEM GUIDES:

A. Manufacturer:

1. Trumbull Industries.
2. Troy Valve.

B. Provide valve stem guides where indicated and as required by the valves manufacturer.

C. Stem Guide Spacing: 6 to 8 feet, maximum slenderness ratio of 200.

D. Stem Guides for Stems 2-inch and Smaller:

1. Materials:
 - a. Stem Guide: Cast Type 316 stainless steel with 2 to 36 inch adjustment.
 - b. Bushing: Bronze, NSF 61
 - c. Hardware: Type 316 stainless steel.

E. Stem Guides for Stems 2-1/8-inch to 4 inch:

1. Materials:
 - a. Stem Guide: Ductile Iron 65-45-12 with 2-3/4 to 17-1/4 inch adjustment.
 - b. Bushing: Split type, Bronze, NSF 61
 - c. Hardware: Type 316 stainless steel.

2.28 POSITION INDICATORS:

A. Manufacturer:

1. Trumbull Industries.
- B. Provide position indicators installed on all multi-turn valves and quarter turn valves with gear boxes 3 inch and larger.
1. Type: Planetary gear design.
- C. Materials:
1. Provide the sun gear, planet gear, ring gears and scale plate constructed of Delrin.
 2. Housings of carbon steel or aluminum are not acceptable.
 3. Hardware and Fasteners: Type 316 stainless steel.
- D. Position Indicator Design Features:
1. Provide the position indication to show the position of the valve, from fully open to fully closed, identified at ground level.
 2. Movement of the indicating arrow must be visible through a window covering a minimum of 300 degrees of the circumference of the indicator.
 3. Size of the characters and numerals: minimum 3/16-inch.
 4. Provide the top scale plate with markings representing the number of turns, contain the word "CLOSED", and a directional arrow.
 5. Provide permanently recessed, embossed or engraved markings in the scale plate. The use of adhesive labels is not acceptable.
 6. Provide the "OPEN" line marked on a transparent polycarbonate window, field adjusted for the number of turns of each valve size.
 7. Provide the position of the adjustable "OPEN" window secured to the top surface of the scale plate by the outside diameter of three Type 316 stainless button head cap screws.
 8. Provide all adapters to secure the position indicator, for installation in either a valve box, floor box or wall bracket as indicated and required.
 9. Provide the position indicator and adapter with matching flat sides to prevent rotation of the indicator during operation.
- E. Exposed and Submerged Valves:
1. Provide a Type 316 stainless steel extension stem connected to a 2 inch square nut on the valve and extend up through the position indicator, terminating in a 2 inch square nut, operable by a standard waterworks tee-handle wrench.

F. Buried Valves:

1. Provide the position indicator installed in a valve box within 6 inches of grade.

G. Valves Installed Inside a Structure:

1. Provide the position indicator installed in a floor box.
2. Where a floor is not directly over the valve and extension stem, support position indicators with a Type 316 stainless steel wall bracket mounted to a side wall.
3. When installed in a floor, provide the adapter with a bronze bushing to support and center the extension stem with the bronze bushing retained in the cast iron floor adapter by two Type 316 stainless steel screws and drilled to an inside diameter 1/16inch larger than the outside diameter of the extension stem.

2.29 PNEUMATIC ACTUATORS

A. Provide rotary type linear constant torque pneumatic actuators for open / close service with the following features:

1. Adjustable open/close speed control
2. Heavy duty mechanical limit switches for open and close status with output feedback.
3. Visual position indicator.
4. Manual over-ride on solenoids.
5. Dual travel stops.
6. 150,000 in-lb.
7. Stainless steel hardware.
8. Alloy steel drive shaft.
9. Epoxy powder coat finish.
10. Spring Return.

B. Manufacturer

1. Bray
2. Kinetrol
3. Keystone

4. K-TORK

2.30 ELECTRIC MOTOR ACTUATORS:

- A. Provide in accordance with Section 40 23 13.03.

2.31 SHOP PAINTING:

- A. Coat internal and external ferrous surfaces of valve with NSF Certified Epoxy in accordance with ANSI/NSF Std. 61, and in conformance to AWWA D102 Inside System No. 1 for all valves not specified to have a fusion bonded epoxy coating.
- B. Process Valve Color: Match piping system.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Prior to installation, protect stored valves and appurtenances from damage due to exposure to sunlight, heat, dirt, debris, freezing and thawing, vandalism, etc.
- B. Clean all debris, dirt, gravel, etc, from inside of piping before placing valves in place.
- C. Erect and support valves in respective positions free from distortion and strain on appurtenances during handling and installation. Inspect material for defects in workmanship and material. Clean out debris and foreign material from valve openings and seats, test operating mechanisms to check functioning, and check nuts and bolts for tightness. Repair valves and other equipment which do not operate easily or are otherwise defective at no additional cost to the Owner.
- D. Set plumb and support valves in conformance with instructions of manufacturer. Shim valves mounted on face of concrete vertically and grout in place. Install valves in control piping for access.
- E. Provide bolted split sleeve coupling or flexible type grooved coupling on downstream side of buried valves to assist in valve removal.
- F. Where indicated provide Type 316 stainless steel stem extension to operating floor elevation as shown and provide the bevel gear operator with a fabricated steel floorstand and handwheel.

3.02 GATE VALVES AND KNIFE GATE VALVES:

- A. Install gate valve stem as shown or with stems between vertical and 45 degrees above the horizontal. Valves installed with stems horizontal or below horizontal are not acceptable.

3.03 CHECK VALVES:

- A. Install check valves horizontally in pipelines unless otherwise indicated.

3.04 PLUG VALVES:

- A. Install valves in horizontal piping with shaft horizontal such that in open position the plug is located in upper part of valve body. Orient valves so that in closed position, flow is against the face of the plug.

3.05 FLOORSTAND OPERATORS AND STEM GUIDES:

- A. Set floorstand operators and stem guides so stems run smoothly in true alignment. Anchor guides to walls. Check distances from centerlines of gates to operating level or base of floorstand and adjust if needed to suit actual conditions of installation.

3.06 VALVE BOXES:

- A. Provide valve box for each buried valve and where indicated.
- B. Set box so top is flush with finished surface and so box does not bear on valve or pipe.

3.07 FIELD TESTING:

- A. Pressure test valves with pipeline pressure testing.
- B. Test functions of each valve.
- C. Make all adjustments necessary to place valves in specified working order at time of above tests.
- D. Remove and replace valves and appurtenances at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the satisfaction of the Engineer that valves will perform the service specified, indicated and as submitted and accepted.

3.08 FIELD TOUCH-UP PAINTING:

- A. After installation and accepted testing by the Engineer, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.09 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 13.03

ELECTRIC MOTOR ACTUATORS AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide 3-phase electric motor actuators and appurtenances as indicated and in compliance with Contract Documents.

- 1. Actuators for all valves, gates, and equipment to be the product of one manufacturer.

1.02 REFERENCES:

- A. ASTM International (ASTM):

- 1. B117: Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - 2. B179: Standard Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from All Casting Processes.

- B. FM Global (FM):

- 1. 3615: Explosionproof Electrical Equipment General Requirements.

- C. Institute of Electrical and Electronics Engineers (IEEE):

- 1. 802.15.4: Standard for Information Technology.

1.03 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00:

- 1. Certified shop and erection drawings.
 - a. Drawings shall be in conformance with all other requirements as specified in this specification.
 - 2. Data, regarding actuator and motor characteristics and performance.
 - 3. Actuator and Valve set-up for each application: Position or torque seating
 - 4. Shop drawing data for accessory items.
 - 5. Manufacturer's literature as needed to supplement certified data.
 - 6. Operating and maintenance instructions and parts lists.

7. Listing of reference installations as specified with contact names and telephone numbers.
8. Actuator shop test results.
9. Motor shop test results.
10. Qualifications of field service engineer.
11. Schematic control and power wiring diagrams.
12. Shop and Field inspections reports.
13. Recommended spare parts other than those specified.
14. Recommendations for short and long term storage.
15. Special tools.
16. Shop and field testing procedures and equipment to be used.
17. Torque capability and settings for each actuator.
 - a. Provide a listing of operating torque, safety factor applied and actuator torque capability and actuator safety factor as specified for each valve, gate and equipment.
18. Number of service person days provided and per diem field service rate.
19. Manufacturer's product data and specifications for shop painting including statement of compliance for compatibility with field painting.
20. Provide a listing of the materials recommended for each service specified and indicated.
21. ISO 9001 certification.
22. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of three (3) years. Provide proposed materials at no additional cost to the Owner.

- b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
 - B. A copy of the contract mechanical process, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required".
 - 1. Failure to include all drawings or a statement application to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
 - C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - 1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.
- 1.04 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
 - B. Provide for each actuator
 - 1. A start-up kit comprising installation instruction manual, electrical wiring diagram and two sets of cover screws and seals to make good any site losses during the commissioning period. Provide all actuator commissioning tools required for actuator set up and adjustment during valve/actuator testing and site installation commissioning.
 - 2. Two fuses of each size and type used in the actuator.
 - 3. One set of back-up batteries for display operation
 - C. Provide spare parts that are identical to and interchangeable with similar parts installed.
 - 1. One set of all special tools

1.05 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 43 00 and as specified herein.
- B. Actuators for all valves, gates and equipment to be the product of one manufacturer.
 - 1. Contractor to coordinate with all valve, gate and equipment suppliers.
- C. Actuators to be manufacturer's standard cataloged product and modified to provide compliance with the specifications and the service conditions specified and indicated.
- D. Shop tests as specified.
- E. Provide Services of Manufacturer's Representative as stated in Section 01 61 00 and as specified herein.
- F. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 - 2. Installation: Inspect setting, alignment, field erection; coordination of, electrical and miscellaneous utility connections:
 - a. 1/2 person-day per actuator.
 - 3. Functional Testing: Calibrate, check the alignment and perform a functional test. Tests to include all items specified.
 - a. 1/2 person-day per actuator.
 - 4. Field Performance Testing: Field performance test equipment specified.
 - a. 1/2 person-day per actuator.
 - 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classrooms sessions.
 - a. 2 person-days, 2 trips.
 - 6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 - 7. Any additional time required of the factory trained service engineer to assist in placing the equipment in operation or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

Electric Motor Actuators and Appurtenances
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- G. Manufacturer of actuators must have at least five (5) operating installations with actuators of the type and size specified and in the same service as specified operating for not less than five (5) years.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Provide in accordance with Section 01 61 00 and as specified

PART 2 - PRODUCTS

2.01 ELECTRIC ACTUATORS – 3-PHASE:

- A. Provide all actuators suitable for use on a nominal 480 volt, 3-phase, 60 Hz power supply.
- B. Provide all actuators incorporating motor, integral reversing starter, local control facilities and terminals for remote control and indication connections housed within a self-contained, sealed enclosure.
- C. Provide actuators meeting the requirements set out in EN15714-2 and ISA SP96.02 unless otherwise indicated or specified
- D. Provide actuators so that setting of the torque levels, position limits and configuration of the indication contacts etc. must be carried out without the removal of any actuator covers and also possible without main power over an Infrared or Bluetooth® wireless interface.
- E. Provide sufficient commissioning tools with the actuators meeting the enclosure protection and certification levels of the actuators.
 - 1. Provide all commissioning tools not an integral part of the actuator and must be removable for secure storage and authorized release. Provide protection of configured actuator settings by a means independent of access to the commissioning tool. Provide the ability to disable Bluetooth® communications or only allow a Bluetooth® connection initiated by an Infrared command for maximum security.
- F. Manufacturers:
 - 1. AUMA
 - 2. Rotork
 - 3. Limitorque
 - 4. Beck
- G. Actuator Sizing:
 - 1. Provide actuators designed and guarantee to close and open valves, gates and equipment at the specified differential pressure, speed, and temperature.

2. Provide actuators with a safety margin of motor power available for seating and unseating the valve, gate or equipment to ensure torque switch trip at maximum torque with the supply voltage 10% below nominal.
3. Operating speed for linear operating valves and gates: approximately 12 inches per minute unless otherwise specified or indicated.
4. Operating Speed for quarter turn valve: Provide operating time as specified and indicated with the optimal actuator and second stage gearbox combination selected to meet sizing requirements.

H. Enclosures:

1. Provide actuators for indoor and outdoor use with a standard corrosivity category, C4 medium durability in accordance with ISO 12944.
2. Provide actuators capable of functioning in an ambient temperature ranging from -22°F to +158°F, up to 100% relative humidity.
3. Provide actuators for hazardous area applications meeting the area classification, gas group and surface temperature requirements as specified and indicated.
4. Enclosure
 - a. Provide actuators O-ring sealed, watertight to IP66/IP68 to 20 m for 10 days, NEMA 4, 6.
 - b. Provide the motor and all other internal electrical elements of the actuator protected from ingress of moisture and dust when the terminal cover is removed.
 - c. Provide the terminal compartment designed to maintain the same ingress protection rating with the terminal cover removed.
 - d. Provide the actuator enclosure designed to allow for temporary site storage without the need for electrical supply connection.
 - e. Provide all external fasteners of Type 316 stainless steel unless otherwise specified and indicated.

I. Motors:

1. Provide motors as an integral part of the actuator, designed specifically for valve and gate actuator applications.
2. Motor: Low inertia, high torque design and class F insulation with class B temperature rise with a time rating of 15 minutes at 104 deg F at an average load of at least 33% of maximum valve or gate torque.

3. Provide temperature limited by two (2) thermostats embedded in the motor end windings and integrated into the actuator control.
 4. Provide electrical and mechanical disconnection of the motor without draining the lubricant from the actuator gearcase.
 5. Provide the actuator with a device that allows the motor to run with the correct rotation for the required direction of valve or gate travel irrespective of the connection sequence of the power supply.
 6. Provide motor protection as follows:
 - a. Stall: Motor must de-energize within 8 seconds in the event of a stall when attempting to unseat a jammed valve or gate
 - b. Over temperature: Thermostat to cause tripping of the motor and auto-reset on cooling
 - c. Single phasing: Lost phase protection.
- J. Direction: Phase rotation correction
- K. Provide a handwheel for manual and emergency operation.
1. Provide a handwheel operator engaged when the motor is declutched by a lever or similar means. Provide the operator of the drive restored to electrical operation automatically by starting the motor.
 2. Provide the system designed so that the handwheel or selection lever does not move on restoration of motor drive.
 3. Provide a HAND/AUTO selection lever to be locked in both hand and auto positions. Provide the ability to select HAND operation while the actuator is running or start the actuator motor while the HAND/AUTO selection lever is locked in HAND without damage to the drive train.
 4. Provide clockwise operation of the handwheel and clockwise movement of the actuator output drive. Provide the actuator handwheel drive mechanically independent of the motor drive and permit valve or gate operation with a manual force not exceeding 90 lbf through stroke and 180 lbf for seating/unseating of the valve or gate.
 5. Provide manual handwheel operation with a lost-motion hammer-blow feature for unseating the valve or gate
- L. Gearing:

1. Provide the actuator gearing totally enclosed in an oil-filled gearcase suitable for operation at any installation angle. Grease lubrication is not acceptable.
2. Drive Gearing: Provide all components of metal construction and incorporate a lost-motion hammer-blow feature.
3. For rising stem valves and gates: Provide hollow type output shaft to accept a rising stem and incorporate thrust bearings of the ball or roller type at the base of the actuator.
4. Provide the design to allow the opening of the gearcase for inspection or disassembly without releasing the stem thrust or taking the valve or gate out of service.
5. For quarter turn valves provide self-locking drive gearing to prevent the valve or gate back-driving the actuator.

M. Drive Interface:

1. Provide the actuator with a detachable drive coupling, for machining to suit the valve stem, gate stem or gearbox input shaft.
2. Provide the drive coupling positioned in the detachable base of the actuator.
3. Provide thrust bearings sealed for life and the base designed to withstand five (5) times the rated thrust of the actuator.

N. Actuator Torque and Limits:

1. Provide torque and stroke limitation, adjustable as follows:
 - a. Position setting range: multi-turn: 2.5 to 8,000 turns, resolution to 7.5 degrees of actuator output.
 - b. Position setting range: part-turn: 90 degree +/-10 degree, resolution determined by gearbox ratio and stroke
 - c. Torque setting: 40% to 100% rated torque.
2. Position measurement:
 - a. Provide absolute position measurement incorporated within the actuator. Provide the technology capable of reliably measuring position even in the case of a single fault.
 - b. Provide the design with the minimum amount of moving parts, maximum 5. Technologies such as LED's or potentiometers for position measurement are not acceptable.

3. Provide torque measurement from direct measurement of force at the output of the actuator. Methods of determining torque using data derived from the motor such as motor speed, current, flux etc. are not acceptable.
4. Provide a means for automatic torque switch bypass to inhibit torque off during valve unseating and latching to prevent torque switch hammer under maintained or repeated control signals.
5. Provide the electrical circuit diagram of the actuator that does not vary with valve and gate type remaining identical regardless of whether the valve or gate is to open or close on torque or position limit.

O. Integral Starter and Transformer

1. Provide reversing starter, control transformer and local controls integral to the valve actuator and housed to prevent breathing and condensation.
2. Provide the starter suitable for 60 starts per hour and of rating appropriate to motor size.
3. Provide the controls supply transformer fed from two of the incoming three phases and incorporate overload protection. Provide the necessary voltage tapping and rated to provide power for the following functions:
4. Energizing of the contactor coils.
 - a. 24VDC or 120VAC output for remote circuits (maximum 5W/VA)
 - b. Supply for all the internal electrical circuits.
5. As an alternative provide a solid-state motor starter for applications requiring up to 1,200 starts per hour. Provide 24VDC remote controls used in combination with a solid-state starter to maximize response time and facilitate configurable electrical braking functionality.

P. Local Controls:

1. Provide the actuator with integral local controls for OPEN/CLOSE operation and include a LOCAL/STOP/REMOTE selector switch.
2. Provide mode selection lockable in any one of the following three positions: LOCAL control plus STOP only, STOP (no electrical operation), REMOTE control plus STOP only. Provide selection of maintained or non-maintained local control.
3. Provide the local controls arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.

4. Provide the local controls and display rotatable through 90 degree increments to suit valve and actuator installation orientation.

Q. Local Position Indication:

1. Provide the actuator display including a dedicated numeric/symbol digital position indicator displaying valve position from fully open to fully close in 0.1% increments.
2. Provide valve or gate closed and open positions indicated by symbols showing valve position in relation to the piping to ensure that valve or gate status is clearly interpreted.
3. With power connected, provide the display backlit to enhance contrast at all ambient light levels and legible from a distance of at least 16 feet. Provide a power save mode available to switch off the display backlight during long periods of inactivity.
4. Provide red, green and yellow LED's corresponding to open, close and intermediate valve, gate or equipment positions on the actuator display when power is switched on. Provide the yellow LED fully programmable for on/off, blinker and fault indication. Provide the digital display maintained and updated during handwheel operation when power to the actuator is isolated.
5. Provide the actuator display with fully configurable dot-matrix display element with a minimum pixel resolution of 168 x 132 to display operational, alarm, configuration and graphical datalogger information.
6. Provide datalogger graphical displays and trend graphs available on the local LCD for the following functions:
 - a. Torque versus Position
 - b. Number of Starts versus Position
 - c. Number of starts per hour
 - d. Dwell Time
 - e. Average temperature
7. Provide the main display configurable with a minimum of four (4) different home screens that include the following information:
 - a. Position and status
 - b. Position and torque (analogue)
 - c. Position and torque (digital)

d. Position and demand (positioning)

8. For all actuators located outdoors provide an environmental cover to protect the display from high levels of UV radiation or abrasive materials and fitted without the need for any special tooling.
9. Provide the local controls and display rotatable through increments of 90 degrees to accommodate actuator installation orientation.

R. Remote Position and Status Indication:

1. Provide four (4) contacts that can be selected to indicate any position of the valve or gate.
2. Provide for the selection of a normally closed (NC) or normally open (NO) contact form.
3. Provide contacts to maintain and update position indication during handwheel operation when all external power to the actuator is isolated.
4. Contacts: Rated for 5mA to 5A, 120VAC, 30VDC.
5. As an alternative to providing valve position indication, provide any of the four contacts configurable to signal one of the following:
 - a. Valve or Gate opening, closing or moving
 - b. Thermostat tripped, lost phase
 - c. Motor tripped on torque in mid travel, motor stalled
 - d. Remote selected, Local selected, Stop selected
 - e. Actuator being operated by handwheel
 - f. Actuator fault
6. Provide the actuator design to support an additional eight (8) contacts with the same configurable functionality.
7. Provide a configurable monitor relay as a standard, which can be used to indicate either Availability or Fault.
8. Relay: Spring return type with a Normally Open (NO) / Normally Closed (NC) contact pre-wired to the terminal block.
9. Provide the monitor (availability or fault) relay, energized from the control transformer and designed to de-energize during any one or more of the following conditions:

- a. Available Mode
 - (1) Loss of main or customer 24VDC power supply
 - (2) Actuator control selected to local or stop
 - (3) Motor thermostat tripped
 - (4) Actuator internal fault
 - b. Fault Mode
 - (1) Loss of main or 24VDC power supply
 - (2) Motor thermostat tripped
 - (3) Actuator internal fault
10. Provide the actuator designed to support the addition of a contactless transmitter to output a 4-20mA analogue signal corresponding to valve, gate or equipment travel and / or torque for remote indication where indicated. Provide the transmitter to auto range to the set limits

S. Remote Control:

- 1. Provide all necessary control, wiring and terminals contained within the actuator enclosure.
- 2. Provide open and close external interlocks available to inhibit local and remote valve opening / closing control. Provide the ability to configure the interlocks to be active in remote control only.
- 3. Provide remote control signals fed from an internal 24VDC or 120VAC supply and/or from an external supply between 20V and 60VDC or 40V and 120VAC, and suitable for any one or more of the following methods of control:
 - a. Open, Close and Stop control
 - b. Open and Close maintained or push to run (inching) control
 - c. Overriding Emergency Shutdown; to close (or open) valve or gate from a normally closed or open contact
 - d. Two-wire control; energize to close (or open), de-energies to open (or close)
- 4. Provide a separate drive enable permissive input to prevent any unwanted electrical operation.

5. Provide the ability to reverse valve or gate travel without the need of stopping the actuator or moving through an intermediate stop control position. Provide the motor starter protected from excessive current surges during rapid travel reversal. Provide the internal circuits associated with the remote control and monitoring functions designed to withstand simulated lightning impulses up to 2kV.

T. Monitoring:

1. Provide the monitoring features as a minimum as standard features of the actuator.
2. Actuator text display indication of the following status/alarms:
 - a. Closed Limit, open limit, moving open, moving closed, stopped
 - b. Torque trip closing, torque trip opening, motor stalled
 - c. ESD active, interlock active
 - d. Thermostat trip, phase lost, 24V supply lost, local control failure
 - e. Configuration error, position sensor failure, torque sensor failure
 - f. Battery low, battery discharged, power loss inhibit
3. Provide integral datalogger to record and store the following operational data:
 - a. Opening last / average torque against position
 - b. Closing last / average torque against position
 - c. Opening motor starts against position
 - d. Closing motor starts against position
 - e. Total open / closed operations
 - f. Maximum recorded opening and closing torque values
 - g. Event recorder logging operational conditions for valve, gate control and actuator
4. Provide the event log to include time and date information for each stored event.
5. Provide the logged data via non-intrusive Bluetooth® communication and also visible on the actuator display.
6. Provide an intrinsically safe portable tool to extract datalogger and actuator configuration files from the actuator. Provide the portable tool Bluetooth® capable

of connection with a PC to perform file transfer. The actuator manufacturer must supply PC software to enable extracted actuator files to be viewed and analyzed.

U. Wiring and Termination:

1. Internal wiring:
 - a. Tropical grade PVC insulated stranded cable of appropriate size for the control and power.
 - b. Provide each wire clearly identified at both ends.
2. Provide the terminals embedded in a terminal block of high tracking resistance compound.
3. Provide the terminal compartment separated from the inner electrical components of the actuator by means of a watertight seal. Provide a minimum of four threaded cable entries with provision for an additional four extra conduit entries to accommodate wiring connections.
4. Provide all wiring supplied as part of the actuator contained within the main enclosure for physical and environmental protection.
5. External conduit connections between components are not acceptable.
6. Provide a terminal identification card showing a plan of terminals attached to the inside of the terminal box cover indicating:
 - a. Serial number
 - b. External voltage values
 - c. Wiring diagram number
 - d. Terminal layout
7. Provide a code card for the contractor to inscribe cable core identification alongside terminal numbers.

V. Local Control Station:

1. Provide a control station device for local control of the actuator for actuators located higher than 6.5 feet above the operating level and up to 328 feet from the installed actuator location.
2. Provide the control station to replicate all of the features and functionality of the actuator HMI and powered solely from the connected host actuator. Provide data extraction from the control station via non-intrusive Bluetooth® communication in the same manner as direct extraction from the actuator HMI. Provide the ability to

enable control arbitration between the control station and the connected host actuator.

3. Provide all electrical components of the control station housed in a double-sealed enclosure with ingress protection rating for outdoor installation and use.
4. Operating temperature range: -58°F to +158°F and 100% relative humidity.
5. For hazardous area applications, provide the enclosure meeting the area classification, gas group and surface temperature requirements specified and indicated.

W. Secondary Gear Boxes:

1. Provide secondary gearing for multi turn or quarter-turn applications where operating times, thrust or torque considerations require.
 - a. Secondary Gearing: Bevel or spur, totally enclosed in a cast iron housing, fully sealed and lubricated for the service indicated and specified.
2. Provide gear assemblies that are a manufacturer's standard selection or combination of as detailed in published product literature.
 - a. Provide each gearbox with a removable output drive coupling sized for the service specified and indicated.
 - b. Provide quarter-turn gearboxes equipped with adjustable mechanical stops (at 0 and 90 degrees +/- 5 percent) to permit limiting open and closed travel during manual operation.
 - c. Factory prime and finish paint all gear boxes with 2 part high solids epoxy or as specified herein for the actuator.

2.02 SHOP TESTS:

A. Actuator Test:

1. Provide each actuator performance tested by the manufacturer. Provide individual test certificates for each actuator at no additional cost to the Owner.
2. Provide the test certificates including:
 - a. Serial number
 - b. Test date
 - c. Manufacturing site address
 - d. Customer

- e. Customer order number (where applicable)
 - f. Actuator size
 - g. Mounting flange
 - h. Enclosure type
 - i. Lubricant
 - j. Paint coating
 - k. Power supply
 - l. Operating speed
 - m. Motor insulation class
 - n. Drive close direction
 - o. Gear ratio for second stage gearbox (where applicable)
 - p. Electrical optional extras
 - q. Catalogue performance
3. Provide the test to simulate a typical valve or gate load and record the following parameters and clearly state on the certificate:
- a. Torque at maximum torque setting in both directions
 - b. Current at maximum torque setting in both directions
 - c. Flash test statement
 - d. Test power supply voltage
 - e. Torque at stall torque in both directions
4. Current at stall torque in both directions
- B. In event that specified tests indicate that actuator will not meet specifications, Engineer has the right to require complete witnessed tests for all motors and actuators at no additional cost to the Owner.
- 1. Repeat tests until specified results are obtained.
 - 2. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

2.03 SHOP PAINTING:

- A. Paint Finish: Baked on polyester powder coating 70 microns thick and must have passed ASTM B117 35 degrees C Salt Spray Test for 1,000 hours.
 - 1. Provide materials for touch-up of all damaged or abraided surfaces due to installation.
 - 2. Ferrous surfaces obviously not to be painted shall be given a shop applied coat of grease or rust resistant coating.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install items in accordance with manufacturer's printed instructions and as indicated and specified.

3.02 FIELD TESTING:

- A. After installation of equipment, and after inspection, operation, testing and adjustment have been completed by manufacturer's field service engineer, conduct running test for each actuator in presence of Engineer to determine its ability to operate without vibration or jamming and to operate at the speeds specified.
 - 1. During tests, observe and record, motor inputs.
 - 2. Promptly correct or replace all defects or defective equipment revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results and results acceptable to the Engineer are obtained.
 - 3. Contractor to provide all labor, equipment, and materials necessary for conducting tests.
- B. Make all adjustments necessary to place equipment in specified working order at time of above tests.
- C. Remove and replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to satisfaction of the Engineer that units will perform the service specified and indicated.

3.03 FIELD TOUCH-UP PAINTING:

- A. After installation and accepted testing by the Engineer. Contractor shall apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 CONTRACT CLOSEOUT:

- A. Provide submittals in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 13.07

SELF-CONTAINED AUTOMATIC CONTROL VALVES AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test self-contained automatic control valves and appurtenances as indicated and in compliance with Contract Documents. Self-contained automatic control valves specified herein are booster pump control valves.
- B. Control valves specified herein are to be used in drinking water application and shall be NSF 61 for use with potable water.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1: Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125 lb.
- B. ASTM International (ASTM):
 - 1. A216: Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
 - 2. A536: Standard Specification for Ductile Iron Castings.
- C. NSF International (NSF):
 - 1. 61: Drinking Water System Components Health Effects.

1.03 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00:
 - 1. Data, regarding valve characteristics and performance including Cv.
 - 2. Shop drawing data for accessory items.
 - 3. Manufacturer's literature as needed to supplement certified data.
 - 4. Operating and maintenance instructions and parts lists.
 - 5. Listing of reference installations as specified with contact names and telephone numbers.
 - 6. Valve shop test results.

7. Qualifications of field service technician.
 8. Shop and Field inspections reports.
 9. List of recommended spare parts other than those specified.
 10. Recommendations for short and long term storage.
 11. Special tools.
 12. Shop and field testing procedures and equipment to be used.
 13. Number of service technician days provided and per diem field service rate.
 14. Manufacturer's product data and specifications for shop painting.
 15. Provide a layout drawing, plan and section showing orientation of valves and nearest obstructions for each valve.
 16. Manufacturer's product data and specifications for shop coating and painting.
 17. NSF 61 certification.
 18. Provide a listing of the materials recommended for each service specified and indicated. Provide documentation showing compatibility with process fluid and service specified and indicated.
 19. The most recent ISO 9000 series certification or quality system plan.
 20. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
 - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
- B. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations and clarifications from the specified requirements.

1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specification and justification are resubmitted with the entire package.

1.04 SPARE PARTS:

- A. Comply with requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Provide enclosures for the area classifications specified and indicated.
- C. Contractor responsible for verifying outside diameter of pipe to be tapped.
- D. Services of Manufacturer's Representative as stated in Section 01 43 00 and specified herein.
- E. Manufacturer of valve shall have a minimum of five (5) operating installations with pumps of the size specified and in the same service as specified operating for not less than five (5) years.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10 and as specified.

PART 2 – MATERIALS

2.01 BOOSTER PUMP CONTROL VALVES:

- A. Manufacturers:
 1. Model 106-PG-BPC by Singer Valve Inc.
 2. Model 60-BY by Cla-Val
- B. Type: Pilot operated, hydraulically actuated, diaphragm design, automatic valve with built-in check valve.
 1. Body Type: Globe body
 2. Provide valve that utilize line pressure as its operating source.

3. Provide valves with all necessary accessories to provide a complete operating unit.
- C. Provide size and configuration as indicated on the Contract Drawings.
- D. End Connections:
 1. Flanged end connections ANSI standard B16.1 of a class to mate with pipe flanges.
- E. Diameter of Seat Opening: Equal to diameter of pipe size.
- F. Provide valves designed to remove and replace all internal parts without removing the valve body from the pipeline.
- G. Provide replaceable seals designed to prevent metal to metal contact.
- H. Pressures:
 1. Operating pressure rating: 150 psi.
 2. Maximum Pressure Rating: 250 psi
- I. Provide a visual position indicator and limit switch. The limit switch shall be used to complete the pump off cycle. The actuating point of the limit switch shall be adjustable.
- J. Materials:
 1. Valve Body and Covers: ASTM A536 (65-45-12) ductile iron or ASTM A216-WCB cast steel.
 - a. Provide a separate stem cap giving access to the stem for alignment check, spring installation and ease of assembly.
 - (1) Provide main bonnet cover and locating pins to accurately locate the main valve body.
 - b. Internal and External Coating: NSF 61 fusion bonded epoxy.
 - c. Provide two NPT connections on each side of the valve body for external control piping and provide Type 316 stainless steel plugs for all unused ports.
 2. Diaphragm: EPDM or Buna N of the rolling type design.
 3. Stem, Nut, and Spring: Type 316 stainless steel.
 4. Disc: Buna-N Rubber.
 5. Trim, disc guide, seat, and cover bearing: Stainless steel.
 6. External Control Piping, Strainers and Valves: Type 316 stainless steel.

7. Tubing and/or hosing: Stainless steel
 8. All internal wetted components of the main valve shall be stainless steel and the coating shall be NSF 61 approved. All pilot system controls, valves, piping and fittings shall be stainless steel. Supplier shall confirm entire assembled valve is NSF 61 compliant.
- K. A direct factory representative shall provide start-up assistance, inspection, and adjustments. The representative shall provide 2 to 4 hours of assistance for each valve installed on the project.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Prior to installation, protect stored valves and appurtenances from damage due to exposure to sunlight, heat, dirt, debris, freezing and thawing, vandalism, etc.
- B. Clean all debris, dirt, gravel, etc, from inside of piping before placing valves in place.
- C. Erect and support valves in respective positions free from distortion and strain on appurtenances during handling and installation. Inspect material for defects in workmanship and material. Clean out debris and foreign material from valve openings and seats, test operating mechanisms to check functioning, and check nuts and bolts for tightness. Repair, valves and other equipment which does not operate easily or are otherwise defective at no additional cost to the Owner.
- D. Set plumb and support valves in conformance with instructions of manufacturer. Shim valves mounted on face of concrete vertically and grout in place. Install valves in control piping for access.

3.02 FIELD TESTING:

- A. Pressure test valves with pipeline pressure testing.
- B. Test functions of each valve.
- C. Make all adjustments necessary to place valves in specified working order at time of above tests.
- D. Remove all replace valves and appurtenances at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the satisfaction of the Engineer that valves will perform the service specified, indicated and as submitted and accepted.

3.03 FIELD TOUCH-UP PAINTING:

- A. After installation and accepted testing by the Engineer, apply touch-up paint to all scratched, abraded, and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 19.01

PIPE SUPPORTS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Design, and provide a complete system of pipe supports with inserts, bolts, nuts, restraining and hanger rods, washers, miscellaneous steel, sliding Teflon plates, and accessories as indicated and in compliance with Contract Documents. The term pipe support includes hangers, guides, restraints, anchors and saddles.
- B. Provide all support systems and the design of all support systems for all piping as specified herein. The Contractor shall provide pipe support locations, configurations and details through accepted shop drawing submittals stamped by a Registered Professional Engineer as specified herein.
- C. The Contractor shall be responsible for the proper design, fabrication, location, shop drawings and installation of all pipe supports in accordance with the specified requirements.
- D. Pipe support locations and types for piping 1/2-inch and larger shall be determined by the Contractor using the guidelines for support spacing specified herein and other criteria contained in this pipe support specification. Guidelines for pipe supports may need to be adjusted based upon field coordination, field routing, or other considerations outlined herein such as structural load limits. The Contractor may revise the pipe support locations and details through accepted shop drawing submittals stamped by a Registered Professional Engineer as specified herein. The Contractor is responsible for the proper design, installation and fabrication of all pipe supports in accordance with the specified requirements. For pipe supports 1/2-inch and larger pipe support shop drawings together with a marked up piping drawing showing support number, location and typical type shall be submitted by the Contractor for acceptance.
 - 1. The Contractor shall be responsible for coordinating all pipe support designs for all trades to ensure compliance with all of the requirements of this specification, including but not limited to the total limitations specified herein.
 - 2. Pipe support details included in plans and specified herein are intended to be guidelines to be used for reference.
- E. Design and provide all temporary pipe supports required during installation and testing.

1.02 REFERENCES:

- A. The American Society of Mechanical Engineers (ASME):

1. B31.1: Power Piping.
2. Boiler and Pressure Vessel Code Section IX

B. ASTM International (ASTM):

1. A36: Standard Specification for Carbon Structural Steel
2. A307: Standard Specification for Carbon Steel Externally Threaded Standard Fasteners
3. A312: Seamless and Welded Austenitic Stainless Steel Pipe
4. A500: Cold Formed Welded and Seamless Carbon Steel Structural Tubing.
5. A572: Specification for Steel Plate.
6. E165: Practice for Liquid Penetrant Inspection Method.
7. E709: Practice for Magnetic Particle Examination.

C. American Welding Society (AWS):

1. D1.1: Structural Welding

D. Fluid Sealing Association: Technical Handbook.

E. Manufacturers' Standardization Society (MSS):

1. SP-58: Pipe Hangers and Supports - Materials and Design.
2. SP-69: Pipe Hangers and Supports - Selection and Application.
3. SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices.
4. SP-90: Guidelines on Terminology for Pipe Hangers and Supports.

F. National Association of Expansion Joint Manufacturers: Standards of the Expansion Joint Manufacturers Association, Inc.

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00:

1. Delegated Design Submittals: For each device, equipment or appurtenance provide written certification from Professional Engineer licensed in the State of Utah stating that supports systems and anchorage for equipment have been designed according to the requirements of Section 1613 of the building codes of Utah, Salt Lake City and ASCE/SEI 7, and in accordance with Specification 01 41 20.

Submit calculations stamped by a Professional Engineer licensed in the State of Utah for support systems and anchorage for wind, seismic, and all other pertinent loads.

2. Pipe support drawings specified herein and including data for accessory items for acceptance prior to fabrication. The Contractor shall submit pipe support coordination drawings including all piping and pipe supports for all trades.
 - a. Detailed drawing of the device with dimensions.
 - b. A table of applied forces and moments.
 - c. A complete bill of materials.
 - d. A unique identification and revision level.
 - e. Seal and signature of a Registered Professional Engineer, registered in the State of Utah, experienced in pipe support design and pipe stress analysis as specified herein.
 - f. Detailed connections to existing structure.
 - g. Indicate all welds, both shop and field, by Standard Units of Measurement as specified in AWS D1.1.
3. Welding Procedure: Submit description required to illustrate each welding procedure to be performed in the specified work.
4. Welding Equipment: Submit descriptive data for welding equipment, including type, voltage and amperage.
5. Qualification for Welders: Provide certification that welders to be employed in work have satisfactorily passed AWS or ASME qualification tests. If recertification of welders is required, retesting is the Contractor's responsibility at no additional cost to the Owner.
6. Pipe support manufacturers' qualifications as specified herein.
 - a. List of at least five (5) successful pipe support projects and current addresses and telephone numbers of persons in charge of representing the owner or the owner of those construction projects during the time of pipe support design, fabrication and installation.
 - b. Qualification of manufacturers' Registered Professional Engineer, registered in the State of Utah, who stamps and seals shop drawings and designs.
7. Coordination drawings for pipe supports shall include as a minimum the following information.

- a. Coordination drawings shall include all pipe supports covered by specifications.
 - b. These coordination drawings will be used by the Contractor to ensure that the pipe supports do not obstruct access, access for equipment operation or removal including all mechanical and electrical equipment, panels, valves, gauges, and instrumentation.
 - c. The Contractor shall be responsible for including and coordinating the work of all subcontractors into the coordination drawings.
 - d. Prepare reproducible coordination drawings, indicating equipment, piping, valves, expansion joints, ductwork, conduit, cable trays, junction boxes, lighting fixtures, sleeves, inserts, embedments, supports, hangers and appurtenances at not less than 1/4-inch scale. Drawings shall show beams, columns, ceiling heights, wall, floors, partitions and structural features as indicated on the contract drawings. Individual pipes and conduit 2-inches or less in diameter that will be field routed need not be shown on coordination drawings.
 - e. Coordination drawings shall include large-scale details as well as cross and longitudinal sections required to fully delineate all conditions. Particular attention shall be given to the location, size, and clearance dimensions of equipment items, shafts, operators and necessary maintenance access.
 - f. Make all minor changes in duct, pipe or conduit routings that do not affect the intended function, but items may not be resized or exposed items relocated without the approval of the Owner. No changes shall be made in any wall locations, ceiling heights, door swings or locations, window or other openings or other features affecting the function or aesthetic effect of the building. If conflicts or interferences cannot be resolved, the Owner shall be notified. Any problems of coordination that require architectural or structural changes of design shall be submitted to the Owner for resolution.
 - g. After the reproducible drawings have been coordinated and all changes have been made, the drawings shall be signed by the Contractor and all subcontractors indicating that all work on that drawing has been coordinated with all associated vendors and subcontractors and all conflicts have been resolved.
 - h. Relocation of any duct, pipe, conduit or other material that has been installed without proper coordination among all trades shall be performed at no additional cost to the Owner.
8. Written notification of any deviations from the requirements of this specification.
9. Support documentation and justification as specified.

10. Certificates of Design signed by a Registered Professional Engineer, registered in the State of Utah, for all pipe supports.
11. Manufacturer's product data and specifications for shop painting.

B. Material Certification:

1. Provide certification from the manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
2. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.

C. A copy of the contract mechanical process, and structural drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required" or provide a statement that no changes are required.

1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
2. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - a. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - b. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.

1.04 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 43 00 and as specified.

- B. Provide manufacturer's certification in writing, that materials meet or exceed minimum requirements as specified.
- C. Welder Qualifications:
 - 1. Qualify and certify welding procedures, welders, and operators in accordance with ASME Section IX for shop welding and AWS D1.1 for project site welding of piping work.
- D. Pipe supports: All supports and parts shall conform to the latest requirements of the Code for Pressure Piping ASME/ANSI B31.1 and Manufactures Standardization Society (MSS) Standard Practice SP-58, SP-69, SP-89 and SP-90 except as supplemented or modified by the requirements of this specification.
- E. Structural Concrete: Conform to the requirements of Section 03 30 00. Concrete strength: 4,000 PSI unless noted otherwise.
- F. Conform to the requirements of the latest edition of the AISC Manual of Steel Construction for miscellaneous and supplementary steel. Tube steels are ASTM A500 Grade B, structural shapes A36, plates A-572 or equal. Stainless steel structural members shall conform to ASTM requirement Type 316L.
- G. Pipe Support Manufacturer Qualifications:
 - 1. Must possess a written quality assurance program.
 - 2. Have a minimum of 5 years experience in the design and fabrication of pipe supports.
 - 3. Have completed the design and fabrication of at least 5 successful pipe support projects of equal size, complexity, and systems as this project within the past 10 years.
 - 4. Retains the services of a Registered Professional Engineer, registered in the State of Utah, with a minimum of ten years experience in the design of piping systems and pipe supports.
 - 5. Manufacturers' Standardization Society (MSS) Member.
 - 6. Have a field service technician on staff with at least 5 years experience in resolving field installation, interference and interface problems associated with the design, installation and manufacture of pipe supporting components.
- H. Hanger inspections shall be performed in accordance with MSS-SP-89 and ASME B31.1.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Provide materials used in pipe supports, which are compatible with the pipes to which they are attached. Provide Type 316L stainless steel supports for all stainless steel piping. Copper plated pipe supports are not acceptable.
- B. Allowable materials: As indicated in ASME/ANSI B31.1 Appendix A and MSS-SP-58 Table 2.
- C. Provide Type 316L stainless steel for pipe supports, hangers, guides, restraints, and anchors that are exterior or interior submerged, in potentially wetted areas in wet wells, channels, screening and grit removal areas and in chemically corrosive atmospheres.
- D. Provide only new material. Previously used and/or scrap material is not acceptable.
- E. Provide tube steels that are ASTM A500 Grade B, Structural shapes A-36, plates A-572 or equal.
- F. Provide sliding Teflon plates. The sliding surfaces shall be a nominal 3/8-inches glass filled Teflon bonded to stainless steel backup plate with a 10 gauge minimum thickness. The bearing pad upper and lower units shall be as follows: Conslide Type CSA elements as manufactured by Con-Serv. Inc., Balco TFE Slide Bearing Plates 10N-cs as manufactured by Balco Inc., or Dynalon Slide Bearings as manufactured by JVI, Inc. or acceptable equivalent product.
 - 1. The blended TFE material used for this bearing shall be composed of virgin (unreprocessed) TFE resin tested per ASTM D1457 and reinforcing agents milled glass fibers. This structural material shall have the following representative mechanical and physical properties:
 - 2. Tensile strength -2,000 psi.
 - 3. Elongation -225 percent
 - 4. Specific Gravity -2.17 to 2.22
 - 5. The coefficient of friction shall average 0.06 under compressive load of 2,000 psi.
 - 6. The compressive creep shall be a minimum of 2 percent at 2,000 psi and 70 degrees F.

7. The elements shall be flat, clean and prepared for installation in the structure. Slots and holes shall be fabricated in the bearing manufacturer's plant.

G. Concrete anchor bolts:

1. Hilti Kwik-Bolt II Stud Anchors.
2. Rawl Bolt.
3. Phillips Wedge Anchors.

2.02 DESIGN, LOCATION, AND TYPE OF PIPE SUPPORTS:

A. Design and provide pipe supports for piping 1/2-inch and larger to include the following loads:

1. Gravity Force: This force includes the weight of pipe, pipe contents (hydro load), valves, in-line equipment, insulation and any other weight imposed on the piping and/or pipe support.
2. Thermal Expansion Force: This force is developed by the restraint of free end displacement of the piping due to thermal growth.
3. Hydrostatic/Dynamic Forces: These forces are developed due to the internal pressure (positive and negative) during operation of the piping system. These forces include the forces due to water hammer, pressure pulses due to rapid valve closure, fluid discharge resulting from pump startup, operation of positive displacement pumps, etc.
4. Wind Loadings: Per Section 01 41 20.
5. Seismic Loading: Per Section 01 41 20 and Section 22 05 48.

B. Provide supports, guides, anchors, flexible couplings and expansion joints in accordance with the coupling and joint manufacturers' specifications and requirements.

C. For all pump suction and discharge nozzles provide an anchor located between the pump nozzles and the nearest expansion joint or non-rigid coupling.

D. Where possible, provide pipe supports, which are the manufacturers' standard products.

1. Provide pipe supports with individual means of adjustment for alignment.
2. Provide pipe supports complete with appurtenances including locking and adjusting nuts.
3. Hanger rods shall be subjected to tension only.

4. Where lateral or axial pipe movement occurs, provide hangers for the necessary swing without exceeding 4 degrees. Provide base supports designed using pipe slides. The bearing surfaces: 0.06 coefficient of friction or less.
 5. Provide concrete inserts capable of supporting the design loads.
 6. Metal framing systems will be acceptable to support piping 2 inch and smaller.
 7. Provide insulated piping supported using rigid load bearing insulation (baton board type) with 16 gauge shields to fit between the insulation and the support. Shields to encompass a minimum 1/3 of the pipe circumference and be 12 inch in length.
 8. Provide load-bearing insulation capable of supporting the load, as a minimum on the bottom 60 degrees of the pipe support. Cope insulation and adjust to avoid interference of steel structures.
 9. Provide supplementary steel as needed.
 10. Do not support pipes from other pipe, conduits or metal stairs.
 11. Chain, strap, T-bar, perforated bar and/or wire hangers are not acceptable.
 12. Contact between piping and dissimilar metals such as hangers, building structural work or equipment subject to galvanic action is not acceptable.
 13. All pipe supports located in fluid flow shall be supplied with double nutting.
- E. Provide thrust anchors to resist thrust where required. Wall pipes may be used as thrust anchors if so designed. Welded attachments shall be of material comparable to that of the piping, and designed in accordance with governing codes.
- F. Provide expansion joints where indicated and where required based on Contractor's design of the pipe support system. Indicate expansion joints on submittal drawings.
- G. For piping 2-inch and smaller provide manufacturer's standard supports and standard spacing guidelines
- H. Pipe supports connected to structural framing and slabs are subject to the following limitations:
1. Less than 100 lbs. horizontal load per support.
 2. Vertical loads not to exceed an average of 10 P.S.F. for slabs, with a maximum vertical load per hanger of 150 lbs.
 3. For a maximum of one pipe support per foot of slab width perpendicular to the span.
 4. Vertical loads not to exceed 500 lbs. per column or 250 lbs. per support at walls.

5. Piping not supported from floors by metal framing must meet the limitations as specified above.

- I. All outside above ground supports shall be Type 316L stainless steel as specified herein.
- J. Provide pipe supports that do not overload or over stress the piping, equipment, or structure that they are supporting or to which they are attached. Allowable pipe stress to be within ASME/ANSI B31.1 code allowable.
- K. The Contractor shall provide the services of a field service technician (preferably from the pipe support manufacturer) to field coordinate the locations of supports and resolve interferences and conflicts encountered during installation.
- L. Where indicated on the Drawings, large diameter pipe supports shall be standard product as provided by Piping Technology & Products, Inc., or approved equal. Custom fabricated saddle supports may be submitted but shall be designed and stamped by professional engineer.

2.03 FABRICATION:

- A. Provide pipe supports formed in accordance with paragraph 5.1 of MSS-SP-58.
- B. Providing welding in accordance with Structural Welding Code.
- C. Provide dimensional tolerances as specified in MSS-SP-89.
- D. Provide threading and tapping in accordance with MSS-SP-89.

2.04 SHOP PAINTING:

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09 96 00.
- B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install items in accordance with manufacturers' printed instructions and as indicated and specified herein.
- B. Perform welding in accordance with Structural Welding Code:

1. Visually inspect welding while the operators are making the welds and again after the work is completed in accordance with AWS D1.1 Section 6.0. After the welding is completed, hand or power wire brush welds, and clean them before the Qualified Inspector makes the check inspection. The Qualified Inspector shall inspect welds with magnifiers under light for surface cracking, porosity, and slag inclusions; excessive roughness; unfilled craters; gas pockets; undercuts; overlaps; size and insufficient throat and concavity. The Qualified Inspector shall inspect the preparation of groove welds for throat opening and for snug positioning for back-up bars.
 2. Nondestructive evaluation of welds connecting structural steel members subjected to critical stresses: Perform in accordance with the weld quality and standards of acceptance in AWS D1.1.
 3. Magnetic Particle Inspection: Perform in accordance with ASTM E709.
 4. Liquid Penetrant Inspection: Perform in accordance with ASTM E165.
 5. For weld areas containing defects exceeding the standards of acceptance in accordance with AWS D1.1, Section 3.7. Provide additional testing of the repaired area at no additional cost to the Owner.
 6. Test Locations: As selected by the Owner.
 7. Correct any deficiencies detected as directed by the Engineer at no additional cost to the Owner.
- C. Proceed with the installation of the pipe supports only after required building structural work has been completed and concrete support structure has reached its 28-day compressive strength as specified in Section 03 30 00.
- D. Install pipe supports to comply with MSS-SP-89. Group parallel runs of horizontal piping to be supported together on trapeze type hangers.
- E. Install pipe supports to provide indicated pipe slopes. Do not exceed maximum pipe deflection allowed by ASME/ANSI B31.1.
- F. For exposed continuous pipe runs, install pipe supports of same type and style as installed for adjacent similar piping.
- G. Install pipe supports to allow controlled movement of piping systems. Permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Piping to be free to move when it expands or contracts except where fixed anchors are indicated or required by the Contractor's pipe support systems. Where hanger rod swing length cannot be provided or where pipe movement based on expansion of

1 inch/100 feet, for each 100 degrees F change in temperature exceed 1/2-inch, provide sliding supports.

- I. Prevent contact between dissimilar metals. Where concrete or metal support is used, place 1/8-inch thick Teflon, neoprene rubber, or plastic strip under piping at point of bearing. Cut to fit entire area of contact between pipe and pipe support.
- J. Prevent electrolysis in support of copper tubing by use of pipe supports which are plastic coated. Electrician's tape is not an acceptable isolation method.
- K. Apply an anti-seize compound to nuts and bolts on all pipe supports.
- L. Locate reinforcing steel in concrete structure with x-ray prior to drilling for embedment plates and anchor bolts. Avoid contact or interference with reinforcing steel.

3.02 INSTALLATION OF BUILDING ATTACHMENTS:

- A. Support piping from structural framing, unless otherwise indicated.
- B. Concrete Inserts:
 - 1. Use existing embedded concrete items whenever possible.
 - 2. Use expansion anchors only when existing embedded attachment points are not available or unsuitable. Attach to hardened concrete or completed masonry.

3.03 THRUST ANCHORS AND GUIDES:

- A. Thrust Anchors:
 - 1. Center thrust anchors between expansion joints and between elbows and expansion joints for suspended piping. Anchors must hold pipe rigid to force expansion and contraction movement to take place at expansion joints and/or elbows and to preclude separation of joints.
 - 2. Restraining rod size and number shall be as indicated and adhere to manufacturers recommendations as a minimum.
- B. Pipe guides: Provide adjacent to sliding expansion joints in accordance with recommendations of the National Association of Expansion Joint Manufacturers and the specific joint manufacturer.

3.04 PIPE SUPPORTS:

- A. Where piping of various sizes is to be supported together, space supports for the largest pipe size and install intermediate supports for smaller diameter pipes.
- B. Provide minimum of two pipe supports for each pipe piece.

- C. Where pipe connects to equipment, support pipe independently from the equipment. Do not use equipment to support piping.
- D. Provide pipe supports so that there is no interference with maintenance or removal of equipment.
- E. Unless otherwise indicated or authorized by the Engineer, place piping running parallel to walls approximately 1-1/2 inch out from face of wall and at least 3 inches below ceiling.
- F. Pedestal pipe supports: adjustable with stanchion, saddle, and anchoring flange. Provide grout between baseplate and floor.
- G. Piping supports for vertical piping passing through floor sleeves: use hot dipped galvanized steel riser clamps.
- H. Support piping to prevent strain on valves, fittings, and equipment. Provide pipe supports at changes in direction or elevation, adjacent to flexible couplings, adjacent to non-rigid joints, and where otherwise indicated. Do not install pipe supports in equipment access areas or bridge crane runs.
- I. Stacked horizontal runs of piping along walls may be supported by metal framing system attached to concrete insert channels.
- J. Do not support piping from other piping.
- K. Designs generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized whenever possible.
- L. Whenever possible, pipe attachments for horizontal piping shall be pipe clamps.
- M. All rigid rod hangers shall provide a means of vertical adjustment after erection.
- N. Where the piping system is subjected to shock loads, such as disturbances due to pump discharge or thrust due to actuation of safety valves, hanger design shall include provisions for rigid restraints or shock absorbing devices.
- O. Hanger rods shall be subject to tensile loading only. At hanger locations where lateral or axial movement is anticipated suitable linkage shall be provided to permit rod swing.
- P. Hanger spacing shall not exceed the spacing listed below:
 - 1. In the case of concentrated loads the supports shall be placed as close as possible to the load to reduce the bending stress.
 - 2. Where changes in direction of the piping system occur between supports, the total length between supports shall be kept to less than three-fourths of the full span.

When practical, a support shall be placed immediately adjacent to any change in direction of the piping system.

- Q. Where practical, riser piping shall be supported independently of the connected horizontal piping. Pipe support attachments to the riser piping shall be riser clamp shear lugs. Welded attachments shall be of material comparable to that of the piping, and designed in accordance with governing codes. If friction is relied upon to support riser piping proper justification and documentation shall be submitted to ensure that enough friction force is provided to resist the applied loading.
- R. Hanger components shall not be used for purposes other than for which they were designed. They shall not be used for rigging and erection purposes.
- S. All threads shall be UNC unless otherwise specified.
- T. TFE slide bearing plates with steel backup plates shall be stitch weld attachments to the structure. A 1/8-inch fillet weld, 1/2-inch long every 3 inches on center each side of an element shall be used unless otherwise indicated or specified by the manufacturers' written recommendations. Bearing elements with slots or holes shall be stitch welded in place for location. The TFE surfaces of the bearings shall be maintained clean and free from grit, dirt or grease.

3.05 INSULATED PIPING:

- A. Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed allowable pipe stresses.
- B. Where vapor barriers are indicated on water piping, install coated protective shields.

3.06 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 19.03

STEEL PIPE AND FITTINGS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Contract shall provide fabrication and installation of steel pipe, specials, and fittings, complete and in place, in accordance with AWWA C200 and as modified herein.
- B. A single pipe manufacturer shall be made responsible for furnishing steel pipe, specials, fittings, and appurtenances such as bolts and gaskets.
- C. A special is defined as any piece of pipe other than a normal full length of straight pipe. This includes, but is not limited to, elbows, manhole sections, short pieces of straight pipe, reducers, tees, and bulk heads.
- D. This specification covers all buried steel pipe 5 feet from Water Treatment Plant and Pump Station but shall include all steel piping within vaults and associated with Clearwell.
- E. Steel pipe, fittings, and specials shall be NSF 61 certified for use with potable water. Certification shall be required for all linings, weld materials, gaskets, and couplings used in conjunction with steel pipelines.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. A36: Standard Specification for Carbon Structural Steel
 - 2. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 3. A307: Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile
 - 4. A325: Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi minimum Tensile Strength
- B. American Society of Mechanical Engineers (ASME):
 - 1. B1.1: Unified Screw Threads
 - 2. B18.2.2: Square and Hex Nuts
 - 3. Boiler and Pressure Vessel Code Section IX

C. American Water Works Association (AWWA):

1. C200: Standard for Steel Water Pipe, 6 Inches and Larger
2. C205: Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4-in. and Larger - Shop Applied
3. C206: Standard for Field Welding of Steel Water Pipe
4. C207: Standard for Steel Pipe Flanges for Waterworks Service, sizes 4 in. through 144 in.
5. C208: Standard for Dimensions for Steel Water Pipe Fittings
6. C222: Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
7. C604: Installation of Buried Steel Water Pipe – 4 inches (100 mm) and Larger

D. Structural Steel Painting Council (SSPC):

1. SSPC-SP6: Commercial Blast Cleaning
2. SSPC-SP10: Near-White Metal Blast Cleaning

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00:

1. Certified shop and erection drawings. Contractor shall submit electronic files of the piping layout including the following.
 - a. Pipe layouts in full detail.
 - b. Location and type of anchors.
 - c. Location of couplings and expansion joints.
 - d. 1/2 inch = 1 foot-0 inches scale details of all wall penetrations and fabricated fittings or special fittings.
 - e. Schedules of pipe, fittings, expansion joints and other appurtenances.
2. Sworn certificates in duplicate of shop tests showing compliance with appropriate standard.
3. Coating and Linings:

- a. Submit catalog cuts and other manufacturer's performance information for products proposed that demonstrate compliance with the Specifications herein described. Provide a copy of approved coating system submittals to the coating applicator. Provide Paint System Data Sheets (PSDS) and/or Material Safety Data Sheets (MSDS) for coating and lining materials.
- b. Quality Control Submittals
 - (1) Applicator's experience with list of references substantiating compliance.
 - (2) If the manufacturer of field-applied coating differs from that of the shop-applied primer, furnish written confirmation from both manufacturers that the 2 coating materials are compatible
- 4. Reports of ASME Section IX welding certifications.
- 5. Catalog cuts of joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.
- 6. Brochures and technical data on coatings and linings and proposed method for application and repair.
- 7. Provide record drawings.
- 8. Provide tag names and numbers for all sections of piping and fittings.
- B. Material Certification:
 - 1. Provide certification from the piping and fittings manufacturer that the materials of construction specified are recommended and designed for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
 - 2. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated.
- C. A copy of the contract mechanical process, civil and structural drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are

required, mark all drawings with “No changes required” or provide a statement that no changes are required.

1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
2. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - a. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - b. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.

1.04 QUALITY ASSURANCE:

A. Welder Qualifications:

1. Qualify and certify welding procedures, welders, and operators in accordance with ASME Section IX, for shop welding and AWS D1.1 for project site welding of piping work.
2. Qualification for welders: Welding shall be performed by welders holding current certification for the welding procedures in use.
3. Visually inspect welding while the operators are making the welds and again after the work is completed. After the welding is completed, hand or power wire brush welds and clean them before the inspector makes the check inspection. Inspect welds for defects exceeding tolerances allowed by code under which the weld was made. Repair all defects exceeding tolerance.

B. Job Conditions:

1. Coordinate dimensions and drillings of flanges with flanges for valves, pumps, and other equipment to be installed in piping system.

C. Coating and Linings

1. All inspection for quality assurance shall ultimately be the responsibility of Contractor. Owner retains the right to observe, accept, or reject the work based on

the results of Contractor's inspection or observations by Engineer, at Owner's discretion, in accordance with the specifications.

2. Coating applicator shall have a minimum of 2 years of experience applying the specified coating system and the application supervisor (Certified Applicator) for the coating application personnel shall have a minimum of 5 years practical experience in application of the indicated products.
3. Coating and/or lining manufacturer technical representative shall be present for a minimum of 3 days to furnish technical assistance and instruction at the start of coating and/or lining operations within the shop and at the Site. During these visits, the technical representative shall observe surface preparation and coating application and conduct tests of the coating to ensure conformance with application instructions, recommended methods, and conditions.
4. Coating and/or lining manufacturer shall furnish 8 hours per month of field or shop coating technical support if requested by Engineer.
5. Technical representative shall provide a written report to Engineer for each visit. Report shall include copies of test data collected, description of observations, and recommended corrective actions. Report shall be submitted within 10 working days after the visit. When deemed necessary by Engineer, work will not be permitted to proceed until the recommended corrective actions have been implemented. After corrective recommendations have been implemented; the manufacturer representative shall return and certify that the application complies with the manufacturer's coating application recommendations.
6. Additional visits by the manufacturer's representative shall be made at sufficient intervals during surface preparation and coating or lining as may be required for product application quality assurance and to determine compliance with manufacturer's instructions, and as may be necessary, to resolve problems attributable to or associated with, manufacturer's products furnished for this project.
7. Repair and recoat all runs, overspray, roughness, or any other signs of improper application in accordance with paint manufacturer's instructions and as reviewed by Engineer.
8. Contractor shall notify Owner and minimum of 14 days prior to the commencement of any work. Contractor shall provide the Owner and/or Engineer with full access to facilities and application documentation. Observation by Owner and/or Engineer, or the waiver of inspection of any particular portion of the work, shall not be construed to relieve Contractor of his responsibility to perform the work in accordance with these specifications.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Provide in accordance with Section 01 66 10.

- B. During loading, transportation and unloading, prevent damage to pipes and coatings. Load and unload each pipe under control at all times. Under no circumstances will a dropped pipe be used unless inspected and accepted by Engineer. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to protect pipe, lining, and coating.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

- A. Northwest Pipe (Special order required)
- B. American Spiral Weld
- C. Utility Coatings and Fabrication
- D. Mid America

2.02 MINIMUM WALL THICKNESS:

- A. Listed herein are minimum wall thicknesses for steel pipe covered in the section. Minimum wall thicknesses are also shown on Contract Drawings; whichever is greater shall govern.
- B. 36" Transmission Main shall be designed for 200 psi working pressure.
- C. Steel pipe 10-inch to 24-inch: ASTM A53 Type E or S, Grade Bc, Black.

Nominal Pipe Size, inches	Outside Diameter, Inches	Minimum Wall Thickness, inches
12	12.75	0.250 (Sch20)
14	14.00	0.250 (Sch10)
16	16.00	0.250 (Sch10)
18	18.00	0.250 (Sch10)
24	24.00	0.250 (Sch10)

- D. Steel Pipe 36-inch diameter and larger: AWWA C200.

Nominal Pipe Size, in	Outside Diameter, inches	Minimum Wall Thickness, inches
36	36.00	0.250
40	40.00	0.250
42	42.00	0.250
48	48.00	0.250

- E. Interior piping wall thickness: Increase wall thickness to limit combined stress (circumferential longitudinal and localized) to 75 percent of the minimum yield of the steel used.

2.03 PIPE:

- A. Fabricate to sizes, dimensions, and shapes indicated.
- B. Seams:
 - 1. Except for seamless mill type pipe, provide piping fabricated from steel plates rolled into cylinders or sections thereof with longitudinal seams or spiral seams butt welded.
 - 2. Do not use more than two longitudinal seams in piping 72 inch and smaller in size.
 - 3. Butt weld girth seams at least 6 feet apart, except in specials and fittings.

2.04 FITTINGS:

- A. Buried fittings 24 inches and greater shall be dimensioned and fabricated in accordance with AWWA C208. Buried elbows shall have a radius of 2.50 times nominal diameter.
- B. Buried fittings less than 24 inches may be standard wrought fittings per ASME B16.9 or may be dimensions and fabricated per AWWA C208.
- C. Provide fittings shop fabricated from previously hydrostatically tested straight pipe with magnetic particle non-destructive testing of all welds that were not previously tested in the straight pipe.
- D. Provide reinforced tees, laterals, and outlets in accordance with ASME Pressure Vessel Code, Section VIII, Paragraph UG-37 or AWWA M11, Chapter 13.
- E. Provide reducing sections with same shell thicknesses required for larger ends.
- F. Special Sections:
 - 1. Provide fittings and special sections with ends as indicated and fabricated to shapes, sizes, and dimensions indicated.
- G. Small Branch Connections:
 - 1. Provide branch connections 2-1/2 inch and smaller fabricated with welding fittings with threaded outlets.
 - 2. Provide branch connections 3 inch through 12 inch fabricated with pipe nipples or with welding fittings.

3. Provide pipe nipples and welding fittings welded to pipe shell and reinforced to meet working and test pressure requirements.
4. Provide pipe nipples of black steel pipe in accordance with ASTM A53 Type E or S Grade B, minimum thicknesses as listed in the above table.
5. Provide threaded and welded outlets as indicated.
6. Provide small branch connections located so as not to interfere with joints, supports, or other details.

2.05 FIELD JOINTS:

A. Type as indicated:

1. Location and type of joint may be modified to provide for lining, coating and flexibility in field assembly as accepted by the Engineer.

B. Provide pipe end preparation and tolerances in accordance with AWWA C200.

2.06 FLANGES, BOLTS AND NUTS:

A. Provide in accordance with AWWA C207. Flanges shall be Class D.

B. Provide flanged end pipe fitted with slip-on flanges. Provide longitudinal or spiral welds ground flush to accommodate type of flanges provided.

C. Provide flanges attached normal to axis of pipe for alignment.

D. Provide flanges tested, after welding to pipe, for true plane and reface, to bring them within specified tolerances.

E. Blind Flanges: Conforming in diameter, drilling, and thickness to flanges to which they mate and reinforced to produce a watertight joint.

F. All buried flanges bolts, and nuts shall be wax tape coated per Section 33 10 00 Water Utilities.

G. Bolts and Nuts:

1. All flanges, both buried and exposed, shall have stainless steel nuts and bolts as follows: Bolts shall have ASME B1.1, Class 2A threads, and be manufactured of ASTM A193, Grade B8M and conform to ASME B18.2.1, and nuts shall have Class 2A fit, square or hex heavy dimensions in accordance with ASME B18.2.2, and be manufactured of ASTM A194, Grade 8B heavy hex.

H. Gaskets:

1. Provide gaskets per AWWA C207. Gaskets shall be a minimum of 1/8 inch thick and shall be NSF 61 certified.
2. Location:
 - a. Ozonated Water - Between Water Treatment Plant and Clearwell, including inside of Clearwell: Garlock Style Stress Saver XP, no approved equal.
 - b. All other Areas: Gylon Style 3505, Gylon Epix Style 3505 EPX, Multi-Swell Style 3760-U, Durlon 7910, Thermoseal WaterSIL, or Teadit Style 1082SAN.

2.07 WELDED JOINTS:

A. Welds:

1. Sound and free from embedded scale or slag, with tensile strength of weld not less than that of thinner of connected sections. Welds to be watertight.
- B. Field welding of lined pipe is not acceptable unless otherwise indicated.
- C. Field welds of interior piping: Butt welds.
1. Outside back-up bar may be used.
- D. Field welds of buried piping: Bell and spigot lap welds with single weld inside or outside.
- E. Provide field welds, in accordance with AWWA C206.

2.08 BOLTED SLEEVE COUPLING:

- A. Bolted sleeve couplings shall be in accordance with AWWA C219. Ends to be joined by mechanical couplings shall be plain end type in accordance with the governing standard and coupling supplier's requirements. Bolted sleeve coupling shall be NSF 61 certified.
- B. Followers shall be constructed of ASTM A36 and middle rings constructed of ASTM A513, A635, or A675 carbon steel. The coupling shall have track-head bolts and hex heavy nuts constructed of ASTM A193, Grade B8M and ASTM A194, Grade 8 (Type 304) stainless steel, respectively. The sleeve coupling gasket shall be constructed of Grade 42 Buna-N or fluorocarbon (FKM, Viton®).
- C. Bolted sleeve couplings shall be furnished complete with bonding wire and brazing cartridges.
- D. Bolted sleeve couplings shall be capable of dynamic movement during service with an allowable angular deflection of 3-degrees.
- E. Bolted sleeve couplings shall be wax tape coated per Section 33 10 00 Water Utilities.

- F. Bolted sleeve couplings shall be Baker Coupling Company, Style 38 by Dresser Industries, Style 400 by Romac, or Model 411 by Smith-Blair.

2.09 DUAL COUPLING HARNESS ASSEMBLY

- A. Dual coupling harness assembly shall only be provided where shown on the Contract Drawings. Assembly shall consist of bolted sleeve couplings and tie-rod restraint harness. Full assembly shall be coated with wax tape coating system as specified in Section 33 10 00 Water Utilities.
- B. Bolted sleeve couplings for assembly shall be as specified herein.
- C. Restrained Harness:
 - 1. Restraint harness shall be tie-rod-lug & gusset type as shown on the Drawings and as designed per AWWA M11 Appendices B and C.
 - 2. Tie-rods shall be grouped around springline to allow differential settlement. Tie-rod restraint assemblies shall consist of ASTM A36 steel lugs, ASTM A193, Grade B8 (Type 304) stainless steel tie-rods, and ASTM A194, Grade 8 (Type 304) stainless steel hex heavy nuts and washers.
 - 3. The tie-rod lugs shall be fabricated to the dimensions shown on the Drawings, as designed through AWWA M11 Appendices B and C.
 - 4. Restraint Harness shall be manufactured/fabricated by UCF, Romac, Dresser Industries, Trumbull Industries, or approved equal.

2.10 HARNESS LUGS AND TIE ROD ASSEMBLY

- A. Harness lugs and tie rod assemblies shall be provided where shown on the Contract Drawings. Assembly shall consist of rectangular steel harness lugs and tie rods. Full assembly shall be coated with wax tape coating system as specified in Section 33 10 00 Water Utilities.
- B. Harness lugs shall be manufactured from ASTM A36 steel and shall be fusion bonded epoxy coated. Lugs shall be compatible with AWWA Class D flanges.
- C. Tie rods shall be type 304 ASTM A193 Grade B8 and nuts shall be ASTM A194, Grade 8 (Type 304) stainless steel hex heavy nuts. Washers shall be type 304 stainless steel.
- D. Harness lugs and tie rod assemblies shall be Series 490 by Romac, or approved equal.

2.11 LINING AND COATING:

- A. General:

1. Exterior and interior pipe and fitting surfaces shall be prepared and coated in accordance with referenced standards, written directions of the coating or lining manufacturers, and this Section, whichever is more stringent.
2. Pipeline coating or lining materials shall be the products of a single manufacturer. Product substitutions during the project will not be considered or permitted.
3. Coating applicator shall provide a monitoring system approved by the coating manufacturer that constantly records pipe and coating conditions during coating application. Recorded monitoring parameters shall include pipe temperature, line speed, surface preparation, holiday test and other parameters applicable to the type of coating.
4. Coatings and linings will be stored, handled and applied per the manufacturer's written directions.
5. Lining and Coating Schedule:
 - a. All buried steel pipe shall be polyurethane coated and cement mortar lined.
 - b. Exposed steel pipe within vaults shall be epoxy lined and coated.
6. Buried dielectrically coated pipe and fittings passing through a structure wall or floor shall be coated for a minimum of 2-inches beyond the interior wall or floor surface or to the inside face of the first interior flange or fitting. Applicator shall confirm compatibility of coatings systems if overlap is required. Overlapping shall be per manufacturers recommendations.
7. Buried lined pipe shall be lined to the inside face of the first interior flange.
8. Provide lining to the interior of steel pipe, fittings, sleeve couplings and maintenance holes.

B. Polyurethane Coating:

1. General: Plural component, polyurethane coating system (referred to as a polyurethane system) shall be applied in accordance with AWWA C 222 and as required herein.
2. Surface Preparation: SSPC-SP10, Near White Metal Blast, 3.0-mil profile, minimum, or as required by the manufacturer, whichever is greater.
3. Coating: Self-priming, plural component, 100 percent solids, non-extended polyurethane, suitable for burial or immersion, and shall be one of the following products or approved equal:
4. Protec II by Futura Coatings

- a. Durashield 210 by Lifelast, Inc.
 - b. Chemthane 2660 by Chemline, Inc
- 5. Thickness: One coat, 35-mils total dry film thickness, minimum, or as required to meet the holiday and coating defects limits of this Section.
 - 6. Holidays: Not to exceed an average of 1.5 holidays per 100 square feet of surface area per 100 square feet of surface area per joint of pipe. Two or more holidays separated by not more than 4 inches center to center will be counted as a single holiday.
- C. Epoxy Lining:
- 1. All epoxy linings applications shall be NSF 61 certified and shall be per Section 09 96 00 High Performance Coatings.
 - 2. Minimum of two coats providing a total dry film thickness of at least 12 mils of liquid epoxy in accordance with AWWA C210.
- D. Cement Mortar Lining:
- 1. All cement mortar lining (CML) materials and applications shall be NSF 61 certified. Provide in-place lining in accordance with AWWA C205.
 - 2. Clean and cement mortar line steel pipe and fittings in accordance with AWWA C205.
 - 3. Cement shall conform to ASTM C150, Type II. Aggregate shall be silica sand or other aggregate that is not subject to leaching. Conform to ASTM C 33. Water for cement mortar: Clean and free from organic matter, strong alkalis, vegetable matter, and other impurities.
 - 4. Shop applied cement mortar lining shall be uniform in thickness over the full length of the pipe joint.
 - 5. Surface preparation and field lining of pipe joints shall be with the same coating system as the shop-applied lining. Field application shall be performed by qualified personnel trained on the proper application of the coating system. Field coating application requirements shall be the same as the shop-applied coating requirements. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application. Pipe supplier shall provide NSF 61 certified CML mix to Contractor for field joint and other lining repairs.
- E. Where sleeve couplings are used, polyurethane coating at pipe ends shall be NSF 61 certified for a distance of 9 inches.

F. EXTERIOR FIELD JOINT COATING

1. Pipe joints shall be field coated after pipe assembly in accordance with AWWA C 216, except as modified herein.
2. Field joint coating shall be compatible with the shop-applied coating system and be provided by the same manufacturer or a manufacturer approved by the pipe coating manufacturer.
3. Field joint coating materials shall be as follows or an equal.
 - a. Heat Shrink Sleeves
 - b. Filler Material: Provide filler material for push-on, flange, and coupling type joints. Filler material shall adhere to pipe and heat shrink sleeves and shall not melt under joint welding temperatures. Size and type shall be as recommended by the sleeve manufacturer for type of pipe and joint.
 - c. Joint Coating: Heat shrink, cross-linked polyolefin wrap or sleeve with an adhesive, backing and sleeve with a total of, 200-mils minimum thickness, suitable for pipeline operating temperature, as recommended by the manufacturer.
 - d. Provide standard recovery sleeve for girth weld or bell and spigot steel pipe joints. High recovery sleeves shall be provided for flange joints, coupling style joints, and ductile iron pipe joints.
 - e. Width of heat shrink sleeves shall be sufficient to overlap existing coating 2 inches minimum. Overlap on tape coated steel pipe shall be based on a sequential 2-inch wide step from outer wrap to middle wrap to inner wrap.
 - f. Consider sleeve shrinkage during installation and joint profile in determining sleeve width required. Overlapping of 2 or more heat shrink sleeves to achieve the necessary width on pipe joints will not be permitted without Owner approval.
 - g. Manufacturers: AquaSleeve by Canusa-CPS, Covalence by Berry CPG, or approved equal.
4. Hand Applied Tape Wrap – Not Allowed.
5. Wax Tape Coating
 - a. Wax tape coatings shall be limited to field application on joints, fittings, or irregular shapes or complex configurations that are not suited for the use of heat shrink or hand-applied tape wrap coating systems.
 - b. Apply coating in accordance with AWWA C217, except as modified herein.

- c. Provide filler material to fill and smooth irregular surfaces, such that no tenting or voids remain under the applied wax tape.
- d. Protect coating from damage and provide special sand backfill protect wax coating from damage.
- e. Coating System
 - (1) Surface Preparation: SP3 Power Tool or SP11 Power Tool to Bare Metal.
 - (2) Primer: Petroleum or petrolatum wax.
 - (3) Filler Material: Filled petroleum or petrolatum wax.
 - (4) Inner Tape: Petroleum or petrolatum wax impregnated fabric, 6-inch width maximum, 40-mils thick.
 - (5) Outer Wrap: PVC or tape suitable for application to inner tape.
- f. Wax tape coating system shall be as manufactured by, or approved equal:
 - (1) Petrolatum Tapes by Denso North American
 - (2) Wax-Tape by Trenton

G. REPAIR OF COATINGS AND LININGS

1. General

- a. Coating or lining repair materials shall be compatible with the shop-applied coating or lining system and shall be approved by the coating or lining manufacturer.
- b. Major repairs on tape wrapped or Polyurethane coatings shall be repaired using heat shrink sleeves as indicated for field joint coating in accordance with AWWA C 216, except as modified herein.
- c. Minor repairs on tape wrapped pipe shall be with heat applied patches.
- d. Coating repairs for polyurethane coating shall be as indicated herein.

2. Coating Repair Materials

- a. Heat Shrink Sleeves (major repair)
- b. Filler Mastic: Provide mastic filler to fill tape void as required.

- c. Full Wrap Coating: Cross-linked polyolefin wrap with a mastic sealant, 85-mil thickness minimum, suitable for pipeline operating temperature, sleeve material recovery as recommended by the manufacturer. Sleeve length shall provide a minimum of 3-inches overlap onto intact pipe coating.
 - d. Manufacturers: AquaSleeve by Canusa-CPS, Covalence by Berry CPG, or approved equal.
- 3. Heat-Applied Patches (minor repair)
 - a. Heat applied adhesive, polyolefin-backed, mastic coated tape, 12-inches maximum size.
 - b. Patch shall provide a minimum of 2-inches overlap onto intact pipe coating.
 - c. Manufacturers: CRP patch by Canusa, PERP patch Berry CPG, or approved equal.
- 4. Polyurethane Coating
 - a. Polyurethane coating system repair shall be in accordance with the coating manufacturer's recommended procedures.
 - b. Pinhole holidays or adhesion test coating repairs shall be with same coating material as for minor repairs or melt stick repairs such as 3M Reactive Adhesive or Canusa Melt Stick.
 - c. Coating material for minor repairs shall be single use kits using syringes or other mix ratio controlled packages of slow set polyurethane coating material similar to the existing coating
 - d. Major repairs will be completed using the same coating material as used for the coating. Surface and adjacent coating shall be abrasively blasted to meet the original coating specifications and to properly roughen the adjacent coating. Coating shall be reapplied using plural component spray equipment by a manufacturer-certified coating applicator.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Handling and Storage: Pipe, specials, and fittings shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, and impact shocks and free fall. Pipe, specials, and fittings shall not be placed directly on rough ground but shall be supported in a manner that will protect the pipe against injury whenever stored at the Site or elsewhere. Pipe, specials, and fittings shall be handled and stored at the Site in accordance with the requirements stated in Part 2, above. No pipe shall be installed when

the lining or coating/interior or exterior surfaces show cracks that may be harmful as determined by Engineer. Such damaged lining and coating/interior and exterior surfaces shall be repaired or a new undamaged pipe, special, or fitting shall be provided at no additional cost to Owner.

- B. Pipe damaged prior to Substantial Completion shall be repaired or replaced at no additional cost to Owner.
- C. Repair of Defects: Patching inserts, overlays, or pounding out defects shall not be permitted. Repair of notches or laminations on second ends shall not be permitted. Deformation of pipe ends through mechanical means or other methods to achieve pipe fit up of defective pipe shall not be permitted. Damaged ends shall be removed to a point of uniform, non-damaged cylinder end and properly prepared. Distorted or flattened lengths shall be rejected. Buckled sections shall be removed and replaced with a full pipe cylinder. Contract shall submit a written repair plan and receive favorable review from Owner prior to the start of any repair work.
- D. Contract shall inspect each pipe, special, and fitting for damage. Contract shall remove or smooth out any burrs, gouges, weld splatter, or other small defects prior to laying the pipe, special, or fitting.
- E. Before placement of pipe, specials, or fittings in the trench, each shall be thoroughly cleaned of any foreign substance that may have collected thereon and shall be kept clean thereafter. For this purpose, the openings of pipes, specials, and fittings in the trench shall be closed during any interruption to the project.
- F. Backfilling on pipe, specials, and fittings shall be done in a controlled manner to avoid damage to polyurethane coating. Buckets of backfilling equipment shall be lowered such that backfill material shall be dropped no higher than 12' to top of pipe. Coatings damaged during backfilling shall be repaired by the Contract.
- G. Pipe, specials, and fittings backfilled with CLSM shall be laid directly on moist sandbags or other suitable supports in preparation for the CLSM pipe zone material. Sandbags shall be placed to provide at least 6-inches of CLSM below the bottom of the pipe. Sandbags shall be spaced at a maximum interval of 8-feet and one set shall be placed within 3-feet on both sides of each joint. Contract shall provide additional sandbags as needed to support the pipe on line and grade. Excavation outside the normal trench section shall be made at field joints as needed to permit adequate access to the joints for field connection operations and for application of coating on field joints.
- H. Installation Tolerances: Each section of pipe, special, or fitting shall be laid in the order and position on the laying diagram and in accordance with the following:
 - 1. Each section of pipe, special, or fitting having a nominal diameter less than 48-inches shall be laid to line and grade, within plus or minus 2-inches horizontal deviation and plus or minus 1-inch vertical deviation.

2. Each section of pipe, special, or fitting having nominal diameter 48-inches and larger shall be laid to line and grade, within plus or minus 5 percent of diameter horizontal deviation and plus or minus 2.5 percent of diameter vertical deviation.
 3. In addition to the horizontal and vertical tolerances above, lay the pipe so that no high or low points other than those on the laying diagram are introduced.
 4. After installation, pipe, specials, and fittings shall not show deflection greater than 1.5 percent for mortar-lined and mortar-coated pipe, specials, and fittings; 2.25 percent for mortar-lined and flexible-coated pipe, specials, and fittings; and 3.75 percent for flexible-lined and flexible-coated or bare pipe, specials, and fittings. The allowable deflection shall be based on the design inside diameter.
 5. Contract shall not permit the pipeline to experience a differential settlement after welding of more than 1.5" over 300 feet.
- I. Where necessary to raise or lower the pipe, specials, or fittings due to unforeseen obstructions or other causes, Contract may change the alignment and/or the grades in accordance with the requirements of the Specifications and Contract Drawings. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings. However, in no case shall the deflection in a joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer without prior approval from Engineer. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint. In all cases the joint opening, before finishing with the protective mortar inside the pipe, shall be the controlling factor.
 - J. Except for short runs, pipes shall be laid uphill if on grades exceeding 10 percent. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. Bends shall be installed as indicated.
 - K. Struts in pipe 30-inches diameter and larger shall be left in place until backfilling operations have been completed. Struts in pipe smaller than 30-inches may be removed immediately after laying. Contract shall monitor pipe deflection by measuring pipe inside diameter before struts are removed and 24 hours after struts are removed. Pipe deflection shall not exceed 3 percent 24 hours after the struts are removed. After the backfill has been placed, the struts shall be removed and shall remain the property of Contract. For pipe backfilled with CLSM, struts shall be left in place until the CLSM backfill has obtained a minimum 7-day cure.
 - L. Cold Weather Protection: No pipe, special, or fitting shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation. No pipe, special, or fitting shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.
 - M. Pipe, Specials, and Fitting Protection: The openings of pipe, specials, and fittings with shop-applied mortar lining shall be protected with suitable bulkheads to maintain a moist

atmosphere and to prevent unauthorized access by persons, animals, water, or any undesirable substance. The bulkheads shall be so designed to prevent drying out of the interior of the pipe, specials, and fittings. Contract shall introduce water into the pipe to keep the mortar moist if moisture has been lost due to damaged bulkheads.

- N. Flotation: At all times, means shall be provided to prevent the pipe from floating. Take necessary precautions to prevent the pipe from floating due to water entering the trench or from backfilling with CLSM. Contract shall assume full responsibility for any damage due to this cause and shall at its own expense restore and replace the pipe to its specified condition and grade if it is displaced due to floating. Maintain the inside of the pipe free from materials and in a clean and sanitary condition.
- O. Pipe Cleanup: As pipe laying progresses, Contract shall keep the pipe interior free of debris. Contract shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying, pointing of joints, and any necessary interior repairs prior to testing and disinfecting the completed pipeline. When pipe laying is not in progress and at the end of each day, Contract shall cover the exposed ends of all pipes to prevent animals, dust, dirt and other debris from entering the pipe.

3.02 WELDED JOINTS

- A. General: Field welded joints shall be in accordance with AWWA C206.
- B. Welding Procedures, Welding Qualifications and Testing:
 - 1. Field welding procedures, welders, welding operators, and tackers shall be qualified in accordance with AWS D1.1 and as defined in Section 3 of ANSI/AWWA C 206 or ANSI/AWWA C 200, as applicable. Qualifications shall be in accordance with all position pipe tests as defined in Section 5 of AWS D1.1.
 - 2. For field welding, the welder qualification testing shall be performed at the Site. Previous qualifications will not be accepted. Contract shall obtain the services of an independent testing laboratory to perform the welder qualification on-Site. Copies of test data and certifications shall be provided to Engineer. Costs for welder qualification testing shall be paid by Contract at no increased cost to Owner.
 - 3. Upon completion of each field-welded joint Contract shall provide a record system that traces a welder's work completion to a specific joint as it relates to the pipeline stationing.
 - 4. Field lap welds shall be inspected by magnetic particle or dye penetration methods. Field butt welds shall be inspected in accordance with the requirements of API 1104 by the radiographic method and the acceptance criteria of API 1104. Magnetic particle testing is not required for seal welds.

5. Double welded lap joints and butt strap joints shall be air tested. Repairs and retesting shall be required if any loss of pressure occurs and shall be at no increased cost to Owner.
 6. Personnel performing the visual inspection of welds shall be qualified and currently certified as Certified Welding Inspector (CWI) in accordance with AWS QC1, Standard for Qualification and Certification of Welding Inspectors. Personnel performing nondestructive tests shall be qualified and certified to meet the requirements of SNT-TC-1A.
- C. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.
 - D. Butt straps shall be as indicated. When fitting up the ends of pipe to be welded or fitting butt-strap pieces, jacking or clamping shall not be allowed. Cold working the metal with sledges or localized application of heat and working the metal with sledges shall not be allowed. If field displacement of joints, where butt strap joints are indicated, does not allow proper fit up with the tolerances indicated, special closure butt straps or mitered pieces shall be shop fabricated and installed.
 - E. A heat resistant shield shall be draped over at least 24-inches of coating beyond the holdback on both sides of the weld during welding to avoid damage to the coating by hot weld splatter. Welding grounds shall not be attached to the coated part of the pipe.
 - F. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.
 - G. To control temperature stresses, the unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe. Shading of the pipe joints need not be performed when the ambient air temperature is below 50 deg F as measured in the trench.
 - H. Temperature Control Joints: At intervals not exceeding 250-feet along welded reaches of the pipeline and at the first regular lap-welded field joints outside concrete encasements and structures, the pipe shall be laid with an initial lap of not less than 1-inch greater than the typical lap dimension. The welding of each such temperature control joint shall be performed when the temperature is approximately the lowest during the 24 hour day, after at least 250-feet of pipe have been laid and the joints have been welded ahead of and in back of the shrinkage control joint, and after backfill has been completed to at least 1-foot above the top of the pipe ahead of and in back of the shrinkage control joint. Where temperature control joints occur in a traveled roadway or other inconvenient location, the location of the temperature control joint may be adjusted, as necessary.
 - I. Prior to the beginning of the welding procedure, any tack welds used to position the pipe during laying shall be removed. Any annular space between the faying surfaces of the

bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then be made in accordance with AWWA C 206. Where more than one pass is required, each pass except the first and final ones shall be peened to relieve temperature stresses, and dirt, slag, and flux shall be removed before the succeeding bead is applied.

- J. Prior to butt welding, the pipe and joint shall be properly positioned in the trench using line up clamps so that, in the finished joint, the abutting pipe sections shall not be misaligned more than 1/16-inch.
- K. Unless double fillet welds are indicated, field welded lap joints may, at Contract'S option, be made on either the inside or the outside of the pipe.
- L. Inspection of Field Welded Joints: An independent testing laboratory shall inspect the joints. Inspection shall be as soon as practicable after the welds are completed.
 - 1. Fillet welds shall be tested by the Magnetic Particle Inspection Method in accordance with ASME Section VIII, Division 1, Appendix VI.
 - 2. In addition, double fillet welds on butt strap joints or double welded lap joints shall be air tested by shop drilling and tapping for 1/4-inch national pipe thread in the lap or bell end of the pipe. Apply 40 psi of air or other satisfactory gas into the connection between the 2 fillet welds. Test pressure shall be measured with a 4-inch diameter, minimum, pressure gauge with a range no greater than 0 to 100 psi. The air test shall consist of holding the test pressure undiminished for 5 minutes. If the air test fails, paint the welds with a soap solution and mark any leaks indicated by the escaping gas bubbles. Leaking portions of the welds or defective welds shall be removed and rewelded. The amount of material removed shall be limited to that required to correct the defect. After the repair is made, the joint shall be checked by repeating the original test procedure to verify that there is no leakage at the inside weld. Close the threaded openings with pipe plugs or by welding them.
 - 3. Butt welds shall be inspected by radiographic methods in accordance with API Standard 1104.
- M. Following tests of the joint, the exterior joint spaces shall be coated in accordance with these specifications after which backfilling may be completed.
- N. Repair of Welds: Welds that are defective shall be repaired by Contract to meet the requirements of this Specification. Defects in welds or defective welds shall be removed, and that section of the joint shall then be re-welded. Only sufficient removal of defective material that is necessary to correct the defect is required. After the repair is made, the joint shall be checked by repeating the original test procedure. Welds deficient in size shall be repaired by adding weld metal.

3.03 JOINT COATING AND LINING

- A. General:

1. The interior and exterior joint recesses shall be thoroughly wiped clean and water, loose scale, dirt, and other foreign material shall be removed from the inside surface of the pipe.
2. Every joint will be tested by Contract with an electrical detector capable of at least a 12,000 volt output, furnished by the Supplier. Holiday tests will be conducted in accordance with NACE RP0274. Holidays shall be repaired by Contract at no additional cost to Owner.
3. Joint Lining: After the backfill has been completed to final grade, the interior joint recess shall be filled with grout. The grout shall be tightly packed into the joint recess and troweled flush with the interior surface. Excess shall be removed. At no point shall there be an indentation or projection of the mortar exceeding 1/16-inch. With pipe smaller than 24-inches in diameter, before the spigot is inserted into the bell, the bell shall be daubed with grout. The joint shall be completed and excess mortar on the inside of the joint shall be swabbed out.

B. ENVIRONMENTAL LIMITATIONS

1. General
 - a. Products shall comply with federal, state, and local requirements limiting the emission of volatile organic compounds and worker exposure.
 - b. Do not apply paint in extreme heat, temperatures below 40 degrees F, nor in dust, smoke-laden atmosphere, damp or humid weather.
 - c. Do not perform abrasive blast cleaning whenever relative humidity exceeds 85 percent, nor whenever surface temperature is less than 5 degrees F above dew point of ambient air. Strictly adhere to manufacturer's recommendations.
 - d. Comply with applicable federal, state, and local, air pollution and environmental control regulations for surface preparation, blast cleaning, disposition of spent aggregate and debris, and coating application.
 - e. Do not perform abrasive blast cleaning whenever the relative humidity exceeds 85 percent or whenever surface temperature is less than 5 degrees above the dew point of the ambient air.
 - f. Do not apply coatings when:
 - (1) Surface and ambient temperatures exceed the maximum or minimum temperatures recommended by the coating manufacturer or these specifications.
 - (2) In dust or smoke-laden atmosphere, blowing dust or debris, damp or humid weather, or under conditions that could cause icing on the metal surface.

- (3) When it is expected that surface temperatures would drop below 5 degrees above dew point within 4 hours after application of coating.
- (4) Whenever relative humidity exceeds 85 percent for polyurethane coating application.
- (5) Where weather conditions or project requirements dictate, Contractor shall provide and operate heaters and/or dehumidification equipment to allow pipe surfaces to be abrasive blasted and coated as indicated and in accordance with the manufacturer's coating application recommendations.
- (6) Work activities may be restricted until adequate temperature and humidity controls are in place and functioning within the environmental limits given.
- (7) Coating applicator shall provide a monitoring system approved by the coating manufacturer that constantly records pipe and coating conditions during coating application. Recorded monitoring parameters shall include pipe temperature, line speed, surface preparation, holiday test, and other parameters applicable to the type of coating.

2. Temperature Control

- a. In cold weather or if moisture collects on the pipe, if the temperature of the pipe is less than 45 deg F, preheat the pipe to a temperature of 50 deg F or 5 degrees above dew point, whichever is greater.
- b. When temperatures are above or below the coating manufacturer's recommended application temperatures, Contractor shall provide temperature controls as necessary to permit the work to proceed within the manufacturer's temperature limitations.
- c. Provide tenting, insulating blankets, baffles, or bulkheads as required to zone and control heating or cooling effectiveness.
- d. Heating shall be with indirect propane fired heaters that do not increase humidity levels within the working area. Heaters shall be sized for the area to be heated.

3. Dehumidification

- a. Contractor shall provide dehumidification equipment when necessary for shop or field environmental control during surface preparation and/or coating application. Dehumidification equipment shall be properly sized to maintain dew point temperature 5 degrees or more below surface temperature of metal surfaces to be cleaned and coated.

- b. Cleaned metal surfaces shall be prevented from flash rusting throughout the project duration; condensation or icing shall be prevented throughout surface preparation and coating application.
- c. Equipment size and power requirements shall be designed by personnel trained in the operation and setup of dehumidification equipment based on project requirements and anticipated weather conditions.
- d. Dehumidification equipment shall operate 24 hours per day and continuously throughout surface preparation and coating application.
- e. Contractor shall use personnel properly trained in the operation and maintenance of the dehumidification equipment or provided adequate training by the dehumidification equipment supplier.
- f. Daily maintenance requirements of the equipment shall be documented in writing and posted near the equipment for review if required by Engineer.
- g. Re-blasting of flash rusted metal surfaces or removal of damaged coatings because of equipment malfunction, shutdown, or other events that result in the loss of environmental control, will be at the sole expense of Contractor.

C. OBSERVATION OF WORK

- 1. Contractor shall give Engineer a minimum of 14 days advance notice of the start of any coating work to allow scheduling for shop or field observation. Notify Engineer a minimum 3 days in advance of actual start of surface preparation and coating application Work.
 - a. Provisions shall be made to allow Engineer full access to facilities and appropriate documentation regarding coating application.
 - b. Observation by Engineer or the waiver of observation of any particular portion of the coating work shall not be construed to relieve Contractor of responsibility to perform the coating in accordance with these Specifications.
 - c. Materials shall be subject to observation for suitability as Engineer may determine, prior to or during incorporation into the work.

D. SURFACE PREPARATION

- 1. General
 - a. Inspect and provide substrate surfaces prepared in accordance with these Specifications and the printed directions and recommendations of coating manufacturer whose product is to be applied.

- b. Visible oil, grease, dirt, and contamination shall be removed in accordance with SSPC-SP1, solvent cleaning.
 - c. Surface imperfections such as metal slivers, burrs, weld splatter, gouges, or delaminations in the metal shall be removed by filing or grinding prior to abrasive surface preparation.
 - d. Protect prepared pipe from humidity, moisture, and rain. Flash rust, imperfections, or contamination on cleaned pipe surface shall be removed by reblasting.
 - e. Priming and coating of pipe shall be completed the same day as surface preparation.
2. Weld Surface Preparation
- a. Application
 - (1) Spray applied coating systems do not require weld grinding.
 - (2) Grind welds on tape wrap coated pipe or apply weld stripe tape over the weld, at the pipe fabricator's option, unless otherwise indicated.
 - b. Weld Grinding: Under the weld grinding option, welds taller than 3/32-inch above pipe surface shall be ground to a tolerance of +3/32-inch to zero-inches above the pipe surface as measured on the highest side of the weld.
 - c. Weld Stripe Tape
 - (1) Weld stripe tape shall be applied to primed metal.
 - (2) Tape shall either have no polyethylene backing or be double sided adhesive tape to permit adhesion of the inner corrosion protection layer to the weld stripe tape.
 - (3) Apply tape with a pressure roller to fully conform the tape to the weld surface.
 - (4) Adhesion of the weld stripe tape shall be the same as for the coating system.
3. Steel Surface Preparation
- a. Surface preparation of steel pipe shall be in accordance with SSPC surface preparation standards utilizing the degree of cleanliness appropriate to the coating system to be applied.
 - b. Grit and/or shot abrasive mixture and gradation shall be as required to achieve the degree of cleanliness and coating adhesion required.

- c. Pipe cleaned by abrasive blasting with recyclable steel grit and/or shot or other abrasive shall be cleaned of debris and spent abrasive in an air wash separator.
- d. Preparation of the steel pipe for the Polyurethane coating system shall have a sharp angular surface profile of the minimum depth indicated.
- e. Work shall be performed in a manner that does not permit the cleaned metal surface to rust back or flash rust.
- f. Rust back or flash rust shall be fully removed with the steel surface cleanliness equal to the required metal surface cleanliness prior to rust back or flash rusting. Determination of the equivalent surface cleanliness shall be at Engineer's sole discretion.

E. SHOP-APPLIED COATING SYSTEMS

1. Polyurethane Coating or Lining

- a. Applicator Qualifications
 - (1) Equipment shall be certified by the coating manufacturer to meet the requirements for material mixing, temperature control, application rate, and ratio control for multi-part coatings.
 - (2) Equipment not meeting the written requirements of the coating manufacturer shall be rejected for coating application until repairs or replacement of the equipment is made to the satisfaction of the coating manufacturer and Engineer.
 - (3) Personnel responsible for the application of the coating system shall have certification of attendance at the coating manufacturer's training class within the last 2 years. The application supervisor (certified applicator) shall be present during all coating application Work and shall have responsibility for controlling all aspects of the coating application.
- b. Coating manufacturer shall provide to Engineer a copy of the manufacturer's coating application quality assurance manual prior to beginning coating application. Strict conformance to the requirements of the manual will be required. Deviation from the requirements of the manual will be grounds for rejecting the applied coating. Rejected coating shall be removed to bare metal and reapplied using proper application methods in accordance with the quality assurance manual and this Section.
- c. Pipe surface temperature shall be between 50 and 100 degrees and 5 degrees above dew point, whichever is greater.

- d. Coating application shall be performed in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer. Application in outdoor conditions will not be acceptable without adequate environmental shelter, environmental controls, and/or dehumidification.
- e. Coating applied under improper environmental conditions will be rejected. Such coatings shall be removed to bare metal and reapplied under proper environmental conditions.
- f. Coating adhesion and holidays testing shall be tested per this Section.
- g. Perform coating and lining repairs per this Section.

F. EXTERIOR COATING HOLDBACK

- 1. Coating holdbacks shall be straight and cut through the full thickness of the coating.
- 2. Cutbacks shall be completed in a manner that permits field coating of joints in accordance with the manufacturer's recommendations and these requirements.
- 3. Holdbacks shall be as required for proper jointing of pipe, considering joint welding requirements, and be as follows:

Polyurethane or Epoxy coating	
Push-on joint, spigot	Flush with spigot end
Push-on, bell	Flush with bell end
Welded, spigot	3-inches, minimum
Welded, Bell	4-inches, minimum

- 4. Holdback Corrosion Protection
 - a. Holding primer for corrosion protection of cutbacks or holdbacks shall be compatible with the joint coating system, shall prevent corrosion of prepared pipe ends for duration of storage and construction, and be recommended for buried exposures.
 - b. Primer shall be compatible with welding operations and shall not result in running or melting of the coating during welding operations.

- c. Application and thickness of holding primer shall be in accordance with the primer manufacturer's recommendations but shall not impair the clearances required for proper joint installation.
- d. Any corroding holdback areas shall be abrasively blasted to SP10 or power tool cleaned to bare metal in accordance with SP11 prior to applying joint coating.

G. PIPE LINING APPLICATION

1. Shop-Applied Cement Mortar Lining

- a. Place mortar lining used in steel piping and steel plate specials in pipe to thickness below.

Pipe Diameter, Inches	Lining Thickness, Inches	Tolerances, Inches
4 through 10	3/8	-1/16, +1/8
11 through 24	5/16	-1/16, +1/8
24 through 36	3/8	-1/16, +1/8
Greater than 36	1/2	-1/16, +3/16

- 2. Centrifugally line straight sections of pipe. Lining of special pieces or fittings shall be by mechanical, pneumatic, or hand placement. Provide cement mortar lining of uniform thickness. Finish to a smooth dense surface.
 - a. Steel plate specials larger than 16-inches in diameter shall have lining reinforced with 2-inch by 4-inch No. 13-gauge welded steel wire mesh.
 - b. Brace and support pipe during lining application to minimize pipe distortion or vibration. Bracing and supports shall not damage the pipe, coating, or lining.
 - c. Tightly close ends of pipe and fittings with plastic sheet caps within 30 minutes of lining application. Plastic end caps shall be of sufficient thickness and strength to resist shipping, handling, and storage stresses.
 - d. Damage to the cement mortar lining, including disbondment, cracking, or blistering, caused by improper curing, shipping, handling, or installation shall be repaired in accordance with AWWA specifications.
 - e. Other requirements of mortar lining materials and processes are in AWWA C205.

H. FIELD COATING JOINTS

1. General

- a. Remove oil or grease contamination by solvent wiping the pipe and adjacent coating in accordance with SSPC-SP1, Solvent cleaning.
- b. Clean pipe surface and adjacent coating of mud, rust, and other foreign contaminants in accordance with SSPC-SP11, Power Tool Cleaning to Bare Metal or abrasively field blast joints in accordance with SSPC-SP10, near white blast, that exhibit any surface rust. Clean the full circumference of the pipe and a minimum of 6-inches onto the existing coating.
- c. Remove loose or damaged pipe coating at joint and either repair the coating or increase the length of the joint coating, where reasonable and practical.
- d. Complete joint bonding (where shown) of pipe joints before application of joint coating. Joint bonds shall be installed per Section 26 42 00 – Galvanic Cathodic Protection System and Section 26 42 05 – Pipe Bonding and Test Stations. Joint bonds shall be low profile bonds, and gaps and crevices around the bonds shall be filled with mastic sealant.
- e. Contractor shall electrically test completed joint coating for holidays with high voltage spark tester.

2. Post-Welding of Joints:

- a. Post-welded joints are defined as welded pipe joints that are coated prior to completing interior welds.
- b. Post welded joints shall be coated and protected as follows:
 - (1) Joint coating shall be heat shrink joint sleeves only. Tape wrapped joints will not be acceptable.
 - (2) Provide 6-inch wide non-shrinking layer centered over the interior weld location, such as CRP patch by Canusa or PERP by Berry CPG patch materials. Heat resistant tape will not be acceptable.
 - (3) Finished external joint coatings shall be fully buried with a minimum of 12-inches of soil cover, prior to any interior welding.
- c. Contractor shall demonstrate that the joint welding procedures will not significantly damage the coating by fully excavating the first 2 post-welded joints for inspection of the coating condition. Up to 3 additional post-welded joints for excavation by Contractor will be selected for inspection of joint coating condition.

- d. Any damage to the external joint coating system will require the Contractor to modify welding methods and or coating materials until a non-damaged system is attainable. All weld damaged joint coatings shall be removed and replaced with the new suitable system.

3. Heat Shrink Sleeve Joint Coating

- a. Store, handle, and apply field heat shrink sleeve coatings in accordance with AWWA C 216 and these specifications.
- b. Store sleeves in shipping box until use. Keep dry and sheltered from exposure to direct sunlight. Store off the ground or concrete floors and maintain at a temperature between 60 and 100 degrees F as recommended by the sleeve manufacturer.
- c. Metal pipe surface shall be free of dirt, dust, and flash rusting prior to sleeve application. Surface preparation shall be in accordance with the joint coating manufacturer's recommendations. At a minimum, surfaces shall be prepared by abrasive blasting to SSPC-SP10 or by power tool cleaning to bare metal in accordance with SSPC-SP11.
- d. Preheat pipe uniformly as recommended by the sleeve manufacturer. Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons. Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
- e. Fill cracks, crevices, gaps, and step-downs greater than 1/4- inch with filler mastic in accordance with the manufacturer's recommendations for the full circumference of the pipe.
- f. Apply heat shrink sleeve when it is at a minimum temperature of 60 degrees F and while maintaining the pipe temperature above the preheat temperature above. Apply sleeve in accordance with the manufacturer's instructions and center the sleeve over the joint to provide a minimum 2 inch overlap onto the existing pipe coating.
- g. Completed joint sleeve shall be fully bonded to the pipe and existing coating surface without voids. Mastic beading shall be visible along the full circumference of the sleeve. There shall be no wrinkling or excessive burns on the sleeves. Sleeves that do not meet these requirements shall be removed and the joint recoated. Minor coating repairs may be made using heat applied patch material indicated.
- h. Allow the sleeve to cool before backfilling. In hot climates, provide shading from direct sunlight. Water quenching will be allowed only when permitted by the sleeve manufacturer.

- i. Heat shrink joint coatings which have become wrinkled or disbanded because of prolonged exposure to UV light or thermal cycling shall be removed and replaced.
- j. Double coating of defective or damaged heat shrink coatings will not be permitted. Any double coated heat shrink sleeves shall be immediately rejected and Contractor shall remove and recoat the joint.

I. REPAIR OF COATING AND LININGS

1. General

- a. Areas where holidays are detected or coating is visually damaged, such as blisters, tears, rips, bubbles, wrinkles, cuts, or other defects shall be repaired. Areas where no holidays are detected, but are visually damaged shall also be repaired.
- b. Maximum defects allowable shall be as indicated for the coating system.

2. Polyurethane Coating or Lining Repairs

a. General

- (1) Complete coating repairs in accordance with the coating manufacturer's written instructions and these Specifications, whichever is stricter.
- (2) Major repairs shall not exceed 2 per pipe joint and the combined area shall not be greater than 50 percent of the pipe.
- (3) Pipes exceeding the maximum number or size of coating defects shall be stripped of coating, reblasted, and recoated at the Contractor's expense.
- (4) Pipe arriving in the field with defects or repairs exceeding the maximum number or size of coating defects will be returned to the shop for recoating at Contractor's expense.

b. Defect Size

- (1) Minor repairs - repairs that are less than 4-inches in the greatest dimension.
- (2) Major repairs - repairs that exceed 4-inches in the greatest dimension.

c. Maximum Quantity of Defects Allowed:

- (1) Minor coating repairs on any joint of pipe shall not exceed 1.5 per 100 square feet of surface area.

- (a) Two or more minor repairs within 6-inches diameter will be considered a single repair.
 - (b) Repairs for adhesion testing will not be included in the total number of repairs.
- (2) Major repairs shall not exceed two per pipe joint and the combined area shall not be greater than 40 percent of the pipe.
- (3) Pipes exceeding the maximum number or size of coating defects shall be stripped of coating, reblasted, and recoated.
- (4) Pipe arriving in the field with defects or repairs exceeding the maximum number or size of coating defects will be returned to the shop for recoating at the Contractor's expense.
- d. Minor repairs shall be repaired using coating repair kits.
 - (1) Surface Preparation: Clean and feather the defect by power tool sanding with 80 grit or coarser sandpaper to roughen the existing coat and feather the edges of the defect for a minimum of 2-inches around the defect.
 - (2) Shop Repairs
 - (a) Slow setting parent material polyurethane coating material in syringes or other single use packaging that controls mix ratio.
 - Coating manufacturer's polyurethane coating repair products subject to Engineer's approval.
 - (3) Field Repairs
 - (a) Melt stick coating repair (not acceptable for repairs greater than one-inch diameter); Scotchkote P206, Canusa Melt Stick, or approved equal.
 - (b) Heat-applied coating materials; CRP Patch by Canusa; PERP Patch by Berry CPG, Tyco Adhesives, or approved equal.
 - (c) Coating manufacturer's polyurethane coating repair products subject to Engineer's approval.
 - (d) Apply a single coat of the patch coating material at the indicated coating thickness.
 - (e) Repairs adhesion shall be at least 50 percent of the indicated coating adhesion.

- (4) Major Repairs:
 - (a) Surface Preparation: The metal surface and surrounding coating shall be abrasively blasted in accordance with SSPC-SP10, near white metal, or equal in cleanliness and profile as the original surface. Existing coating shall be feathered and roughened to the equivalent of 40 grit sandpaper.
 - (b) Shop Repairs: Same material as the pipeline coating and shall be applied by using plural component spray equipment.
 - (c) Field Repairs: Same material as the pipeline coating and shall be applied by using plural component spray equipment, Heat shrink sleeves as for pipeline joints. The metal surface and surrounding coating shall be re-blasted to equal cleanliness and profile as the original surface preparation. Existing coating shall be feathered and roughened to the equivalent of coarse sandpaper by abrasive blasting.
- (5) One coat of the original coating material shall be applied over the repaired surface at the indicated thickness.
- (6) Repair adhesion shall be equal to the indicated coating adhesion.

J. INSPECTION AND TESTING

- 1. Inspection
 - a. Applicator shall inspect and test the coating system in accordance with referenced standards and these specifications, whichever is more stringent.
 - b. The frequency of the testing shall be determined by the applicator, but shall not be less than the requirements of this specification.
 - c. Contractor will conduct random independent inspections and tests for the final acceptance or rejection of pipe coating or lining.
- 2. Adhesion Testing, General
 - a. Adhesion testing shall be conducted at the shop prior to shipment. Pipe shipped without adhesion testing will be field-tested. Pipe rejected in the field will be returned to the shop for repair at the sole expense of the Contractor.
 - b. A minimum of 2 pipes will be tested for adhesion from each lot of pipe coated up to 4,000 square feet of pipe. An additional adhesion test will be conducted on every increment up to 3,000 square feet of pipe coated in excess of the first 4,000 square feet of pipe. (i.e., if one workday of production is 8,000 square feet of pipe, 4 adhesion tests will be conducted on the pipe lot.

- c. A pipe lot is defined as the quantity of pipe that is coated by a single crew within a work shift, but not to exceed 12 hours.
- d. The pipe coating applicator shall repair coating damage from adhesion testing.
- e. Adhesion tests will be performed not less than 24 hours after coating application. Tests conducted prior to 24 hours will be acceptable only if the test meets or exceeds the adhesion criterion and the test was requested by the pipe fabricator.
- f. Pipe will be randomly selected for adhesion testing.
- g. If any pipe tested fails the adhesion test, all pipes within the lot will be rejected. Each pipe within the rejected pipe lot will then be individually tested for adhesion and accepted or rejected on a pipe-by-pipe basis.
- h. Rejected pipe shall have the coating fully removed from the pipe and the pipe abrasive blasted and recoated.

3. Adhesion Testing, Polyurethane

- a. Polyurethane coatings shall have an adhesion to steel of 1,750 pounds per square inch, minimum.
- b. Polyurethane coating adhesion to steel substrates shall be tested using pneumatic pull off equipment in accordance with ASTM D 4541 and AWWA C 222, except as modified in this Section.
- c. Adhesion testing records shall include pipe identification, surface tested (interior or exterior), surface temperature, coating thickness, tensile force applied, mode of failure, and percentage of substrate failure relative of dolly surface.
- d. Dollies for adhesion testing shall be glued to the coating surface and allowed to cure for a minimum of 12 hours. Because of high cohesive strength, polyurethane coatings shall be scored around the dolly prior to conducting the adhesion test.
- e. Failure shall be by adhesive and cohesive failure only. Adhesive failure is defined as separation of the coating from the steel substrate. Cohesive failure is defined as failure within the coating, resulting in coating remaining both on the steel substrate and dolly.
- f. Partial substrate and glue failures will be retested if the substrate failure is less than 50 percent relative of the dolly surface area and the applied tension was less than the adhesion criterion. Pipes that have partial substrate failures greater than 50 percent and less than the required adhesion will be rejected as a substrate adhesion failure.

- g. Glue failures in excess of the minimum required tensile adhesion would be accepted as meeting the adhesion requirements.
 - h. Adhesion tests will be conducted all polyurethane pipe coating.
 - i. Repair patches on the polyurethane coating shall be randomly selected for adhesion testing in a manner as described herein and at the discretion of the coating inspector conducting the adhesion tests. Adhesion of repairs shall be as indicated for the type of repair.
- 4. Holiday Testing
 - a. Holiday test the inner layer of tape wrap coatings after application and prior to the subsequent tape layer in accordance with AWWA C 214 and NACE Standard RP 0274.
 - b. Holiday tests on polyurethane coatings shall be conducted on the completed coating after cure or 24-hours, whichever is less, using a high voltage spark test in accordance with NACE Standard RP 0274 and these specifications.
 - c. Coating thickness used for holiday testing shall be the minimum coating thickness.
 - d. Dry Film Thickness Testing
 - (1) Coatings shall be tested for dry film thickness using a properly calibrated magnetic pull off or eddy current equipment.
 - (2) Coating thickness measurements shall be conducted as necessary and without limitation. Testing conformance to the requirements of SSPC PA-2 is specifically excluded from this specification.

K. HANDLING, TRANSPORTATION, AND STORAGE

- 1. Coated pipe shall not be shipped or installed until coating has developed full adhesion and cure.
- 2. During coating application, storage, loading, and transportation, every precaution shall be taken to protect and prevent damage to pipe, lining, and coating. Forklift equipment shall have load-bearing surfaces padded with suitable material. Lift pipe with web slings a minimum of 12-inches wide and of a type that will not damage the coating. Metal chains, cables, tongs, forklifts or other equipment likely to damage the coating will not be permitted. Dragging or skidding of pipe on grade or in the trench will not be permitted.
- 3. Provide transportation vehicles with padded bolsters between each layer of pipe and heavy padding under load ties. Bolsters shall be curved to fit the outside of the pipe and 12-inches wide, minimum. Pipe contact locations shall be heavily padded with

carpet and strips of the outer tape wrap material (adhesive side against the carpet) during shipment to the Site and from the storage yard to the point of installation.

4. Pipe shall not be stored on rocks, gravel, or other hard materials that might damage the coating. Provide padded 12-inch wide skids and chucks, sand bags, select loamy or sand berms, or suspended from cutback ends, where possible, to minimize coating damage. Pipe shall not be laid on asphalt without suitable padding at contact points.
5. Pipe shall be inspected by Contractor at the Site for damage. Any damage to the pipe, lining, or coating shall be repaired if a satisfactory repair can be made; otherwise, the damaged section shall be replaced at the sole expense of Contractor.
6. No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. Workers shall not be permitted to walk on the coating except when absolutely necessary. When required, shoes with rubber or composition soles and heels or other suitable footwear that will not damage coating shall be used.
7. Long-term Exposure: Pipe shall either be provided with UV inhibitor for length of above grade exposure or covered to prevent UV degradation of outer wrap. Amount of UV stabilizers required shall depend on the project location, laying schedule, anticipated length of exposure, and type of outer wrap. Coating manufacturer shall be consulted for recommended UV inhibitors requirements or pipe shall be stored under a protective cover. Protective covering can be colored plastic sheeting, canvas, or other UV blocking material. Clear plastic sheets are not acceptable. Areas of coating that display UV degradation shall be removed and repaired at sole cost of Contractor.
8. End Caps: Pipe ends of mortar lined pipe and fittings shall be tightly closed with a plastic wrap to aid in curing and to minimize drying out of and contamination of the lining. Plastic end cap shall consist of a minimum of one 10-mil sheet of polyethylene or other suitable material. End caps shall be substantial enough to resist shipment, handling, and storage loads and to remain firmly attached in place. The plastic end cap shall remain intact and in place until pipe installation. Damaged or missing plastic end caps shall be repaired or replaced.
9. Bracing
 - a. The manufacturer shall install adequate bracing or strutting to keep the pipe from becoming deformed or damage from occurring to the coating or linings. Strut-type bracing shall be installed as soon as possible after application of lining. Struts shall remain in place during handling, storage, transportation, and installation of pipe and fittings until after the pipe zone material is compacted. Adequate strutting shall be provided by pipe manufacturer, so that after completion of backfilling, pipe deflection or elongation shall not exceed one percent of the nominal inside diameter of cement-mortar-lined pipe.

- b. The minimum bracing shall consist of crossed struts (horizontal and vertical). The maximum spacing along the pipe shall be near each end and at the one-third points for each 48-foot section of pipe, with a minimum of 4 sets of struts per 48-foot section of pipe. Random lengths of pipe shall have an equivalent number of sets of struts, with a minimum of one set of struts in a 10-foot section of pipe
- c. The struts shall be installed with pads and wedges in such a manner that the pipe lining will not be damaged and the struts will not be dislodged during shipping and handling of the pipe. If struts are welded, they shall be installed and removed in such a manner to prevent damage to the steel cylinder, lining, or coatings. Damage shall be repaired to the satisfaction of Engineer.

3.04 INSTALLATION OF PIPE APPURTENANCES

- A. Installation of Valves: Valves shall be handled in a manner to prevent any injury or damage to the valve or any part of it. Joints shall be thoroughly cleaned and prepared prior to installation. Contract shall adjust stem packing and operate each valve prior to installation to verify proper operation.
- B. Valves shall be installed so that the valve stems are plumb and in the location indicated.
- C. Buried valves and flanges shall be coated and protected in accordance with Section 09 98 10 - Pipeline Coatings and Linings.
- D. Installation of Flanged Joints: Before the joint is assembled, the flange faces shall be thoroughly cleaned of foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges. Bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable calibrated torque wrench. Clamping torque shall be applied to the nuts only.
- E. Insulated Joints: Insulated joints and appurtenant features shall be provided where indicated on the Contract Drawings. Contract shall exercise special care when installing these joints to prevent electrical conductivity across the joint. After the insulated joint is completed, an electrical resistance test shall be performed by Contract. If the resistance test indicates a short circuit, Contract shall remove the insulating units to inspect for damage, replace all damaged portions, and reassemble the insulating joint. The insulated joint shall then be retested to assure proper insulation.
- F. Flexible Coupled Joints: When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings, and gaskets are clean and free of dirt and foreign matter with special attention given to the contact surfaces of the pipe, gaskets, and couplings. The couplings shall be assembled and installed in conformity with the recommendation and instruction of the coupling manufacturer.
- G. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular

space between the follower rings and the body of the pipe. Bolts shall be tightened approximately the same amount. Diametrically opposite bolts shall be tightened progressively and evenly. Final tightening shall be done with a suitable calibrated torque wrench set for the torque recommended by the coupling manufacturer. Clamping torque shall be applied to the nut only.

3.05 CORROSION CONTROL

- A. Joint Bonding/Electrolysis Test Stations: All non-welded pipeline joints shall be bonded as shown on the Drawings.
- B. Cathodic Protection: Corrosion mitigation and testing materials, such as an impressed current cathodic protection system, test stations, pipe bonding, and other associated components shall be provided in accordance with the Contract Drawings and Specifications.

3.06 MARKING TAPE INSTALLATION

- A. Continuously install metallic marking tape along the pipe at the depth and location indicated.
- B. Continuously install plastic marking tape along the pipe at the depth and location indicated.

3.07 PHYSICAL CHECKOUT, FIELD, AND FUNCTIONAL TESTING:

- A. Clean dirt, dust, oil, grease, and other foreign material, before pressure and leakage tests.
- B. Water for testing provided by the Owner. All other temporary facilities for testing shall be provided by the Contractor.
- C. Pressure and Leakage Tests shall be done per C604:
 - 1. Provide temporary testing plugs or caps, pressure pumps, pipe connections, meters, gages, equipment, and labor. Temporary facilities are not shown on the Contract Drawings but shall be provided as required for testing.
 - 2. Test pipelines in sections of accepted length and by pipe material. Steel pipe sections shall be tested separately from ductile iron pipe sections.
 - 3. Fill section of pipe with water and expel air. Leave water in pipeline for 24 hours to allow the CML to absorb as much water as possible.
 - 4. Pressure and leakage test shall consist of pressurizing the section of steel pipe to 250 psi and holding for 2 hours. The minimum allowable test pressure of 250 psi shall be calculated or measured at the highest elevation in the section being tested. The calculated or measured pressure in the section being tested shall be not be greater than 270 psi.

5. Once pressure is achieved it shall be maintained for 2 hours with no allowance for makeup water or test has failed. Any visible leakage shall also indicate a failed test.
 6. If section fails pressure and/or leakage test, locate, uncover, and repair or replace defective pipe, fitting, or joint, and conduct additional tests and repairs until section passes test at no additional cost and without any time extensions.
- D. Make piping connections to equipment with pipe in a free supported state and without application of vertical or horizontal forces to align piping with the equipment flanges.

3.08 FIELD PAINTING:

- A. Provide in accordance with Section 09 96 00.

3.09 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 19.04

DUCTILE IRON PIPE AND FITTINGS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test ductile iron pipe, fittings and appurtenances as indicated and in compliance with Contract Documents.
- B. Options:
 - 1. For buried exterior pipelines provide push-on joint pipe.
 - a. Provide restrained push-on pipe as specified.
 - b. Provide either restrained push-on joint fittings as specified and indicated or provide mechanical joint fittings with restraint system as specified herein.
 - 2. For piping exposed as in buildings and galleries, provide flanged pipe and fittings.
 - 3. Cast iron pipe and fittings are not acceptable.
- C. Ductile iron pipe and fittings shall be NSF 61 certified for use with potable water. Certification shall be required for all pipe materials, linings, and gaskets.

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. A193: Standard Specification for Alloy-Steel and Stainless-Steel Bolting Materials for High-Temperature Service
 - 2. A194: Standard Specification for Carbon Steel, Alloy Steel, and Stainless-Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- B. American Water Works Association (AWWA):
 - 1. C104: Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
 - 2. C110: Ductile-Iron and Gray-Iron Fittings, 3 in. through 48 in., for Water and Other Liquids
 - 3. C111: Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe Fittings
 - 4. C115: Flanged Ductile-Iron Pipe with Threaded Flanges

5. C150: Thickness Design of Ductile-Iron Pipe
6. C151: Ductile-Iron Pipe, Centrifugally Cast in Metal Molds, or Sand-Lined Molds, for Water or Other Liquids
7. C153: Ductile-Iron Compact Fittings, 3-in through 16-in. for Water and Other Liquids

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00:

1. Pipe manufacturer's technical specification and product data.
2. Certified shop and erection drawings. Contractor shall submit electronic files of the piping layout including the following.
 - a. Pipe layouts in full detail.
 - b. Location of hangers and supports.
 - c. Location and type of anchors.
 - d. Location of couplings and expansion joints.
 - e. 1/2-inch = 1 foot-0 inch scale details of all wall penetrations and special fittings.
 - f. Schedules of pipe, fittings, special castings, couplings, expansion joints and other appurtenances.
3. Certificates: Sworn certificates in duplicate showing compliance with material used and shop tests performed.
4. Catalog cuts and technical data for expansion joints, couplings, gaskets, pipe supports and other accessories.
5. Brochures and technical data on coatings and linings and proposed method of application.
6. Manufacturer's descriptive literature and technical data on insulation and proposed method of installation.

B. Material Certification:

1. Provide certification from the pipe and fittings manufacturer that the materials of construction specified are recommended and designed for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and

certification that the proposed materials are recommended and designed for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.

2. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated.
- C. A copy of the contract mechanical process, civil and structural drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with “No changes required” or provide a statement that no changes are required.
1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
 2. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - a. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - b. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.

1.04 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 43 00 and as specified.
- B. Provide manufacturer's certification in writing, that materials meet or exceed minimum requirements as specified.
- C. Inspect and test at foundry according to applicable standard specifications.
- D. Owner reserves right to inspect and test by independent service at manufacturer's plant or elsewhere at his own expense.
- E. Visually inspect before installation.

F. Job Conditions:

1. Coordinate dimensions and drillings of flanges with flanges for valves, pumps, and equipment to be installed in the piping systems.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. During loading, transportation and unloading, prevent damage to pipes and fittings. Load and unload each pipe under control at all times. Under no circumstances will a dropped pipe be used unless inspected and accepted by Engineer. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation.

PART 2 - PRODUCTS

2.01 PIPE:

A. Ductile Iron:

1. Design conforming to AWWA C150.
2. Manufacture conforming to AWWA C115 or AWWA C151.
3. Pipe class, unless otherwise indicated or specified:
 - a. 36-inch Transmission Main:
 - (1) Pressure Class 150, minimum.
 - (2) Flanged pipe shall be Thickness Class 53.
 - b. Pipes less than 36-inch nominal: MJ and flanged pipe - Thickness Class 53.

2.02 PIPE FOR USE WITH COUPLINGS:

- A. As specified above except ends shall be plain.
- B. With bolted split sleeve couplings, ends cast or machined at right angles to axis.

2.03 FITTINGS:

- A. All 36-inch diameter fittings shall be MJ type unless indicated otherwise on the Contract Drawings. Fittings for pipes less than 36-inch diameter shall be MJ type or flanged as shown on the Drawings.
- B. MJ fittings shall be pressure rated 250 fittings conforming to AWWA C110 or AWWA C153.

- C. Flanged fittings shall conform to AWWA C110, AWWA C111, and ANSI B16.1 Class 150(125) and shall have either raised or plain faces and shall have a minimum working pressure rating of 135 psi.

2.04 WALL CASTINGS:

- A. Provide size and type indicated on the Contract Drawings. Minimum thickness shall be Thickness Class 53.
- B. Wall Castings: Conform to requirements of AWWA C110. Fabricated fittings shall not be allowed. Screwed on mechanical or push-on joints are not acceptable.

2.05 SOLIVE SLEEVE-TYPE COUPLINGS:

- A. Solid sleeve-type couplings shall be provided where shown on the Contract Drawings. Coupling shall be of ductile iron and shall be of the size to fit the pipe and fittings shown. Coupling shall be pressure rated 135 psi and comply with AWWA C110. Restraints shall be provided where indicated on the Contract Drawings.
- B. All buried couplings shall be wax tape coated per Section 33 10 00 Water Utilities.

2.06 BOLTED SLEEVE TYPE COUPLINGS:

- A. Sleeve-type couplings shall be provided where shown on the Contract Drawings. Couplings shall be of ductile iron, without pipe stop, and shall be of sizes to fit the pipe and fittings shown. Coating shall be fusion bonded epoxy. Couplings shall be pressure rated for 150 psi and comply with AWWA C219.
- B. All buried couplings shall be wax tape coated per Section 33 10 00 Water Utilities.
- C. Couplings shall be Style 501 or FC1 by EJ Prescott, Style 501 by Romac, or approved equal.

2.07 RESTRAINED BOLTED SLEEVE-TYPE COUPLINGS

- A. Restrained bolted sleeve-type couplings shall be provided where shown on the Contract Drawings. Couplings shall be of ductile iron or ASTM A283 Grade C steel, without pipe stop, and shall be of sizes to fit the pipe and fittings shown.
- B. Coating shall be fusion bond epoxy. Couplings shall be the rated for 150 psi and comply with AWWA C219. Sleeve length shall be 7 inches for pipe diameters 4-inch through 12-inch and 10 inches for pipe diameters 14-inch and larger.
- C. Restraint gland shall be ductile iron meeting the requirements of ASTM A 536.
- D. All buried couplings shall be wax tape coated per Section 33 10 00 Water Utilities.
- E. Couplings shall be Series 470 by Smith-Blair, Style 400RG by Romac, Series 3800 by EBAA Iron, Inc., or approved equal.

2.08 JOINTS:

1. All joints for 36-inch Transmission Main shall be push-on type unless indicated otherwise on the Contract Drawings. Joints shall be restrained when indicated on the Contract Drawings.
2. All joints for piping less than 36-inch nominal shall be restrained MJ type or flanged, as indicated on the Contract Drawings. All joints inside vaults and pump station shall be flanged, unless noted otherwise.
3. Pipe flanges shall be flat faced flanges and gaskets shall be 1/8-inch thick, full faced type.
4. Provide restrained joint on pipe where indicated. Provide restrained joint which is boltless and capable of being deflected after assembly. Designs using set screws or requiring field welding are not acceptable.
5. Manufacturers:
 - a. American Cast Iron Pipe Co. Flex-Ring
 - b. McWane Ductile TR Flex
 - c. U.S. Pipe TR FLEX

2.09 RESTRAINT SYSTEM:

- A. Provide restraint devices for pipe consisting of multiple gripping wedges and tie rods.
 1. Joint restraint shall require conventional tools and installation procedures per AWWA C600, retaining full joint deflection during assembly and allowing joint deflection after assembly.
 2. Provide actuation of the gripping wedges ensured with torque limiting twist off nuts.
- B. All buried restraints shall be wax tape coated per Section 33 10 00 Water Utilities.
- C. Working Pressure Rating:
 1. 16-inch and Smaller: 350 psi
 2. 18-inch thru 36-inch: 250 psi
 3. Minimum safety factor: 2 to 1
- D. Materials:
 1. Gland body, wedges and wedge actuating components: Grade 65-45-12 ductile iron in accordance with ASTM A536.

2. Ductile iron gripping wedges: Heat treated, 370 to 470 BHN.
 3. Coating shall be a minimum of two coats of liquid thermoset epoxy coating with heat cure to follow each coat.
- E. Manufacturer:
1. EBAA Iron MEGALUG Series
 2. Star Pipe Products Series 3000 or Series 3100.
- 2.10 FILLING RINGS:
- A. Provide where necessary.
 - B. Materials, workmanship, facing, and drilling, conforming to 125-lb. ANSI (Class 125).
 - C. Suitable length with nonparallel faces and corresponding drilling, if necessary, for correct assembly of adjoining piping or equipment.
- 2.11 PIPE COATINGS:
- A. The exterior of buried pipe and fittings shall be an asphaltic coating approximately one-mil thick.
 - B. All exposed piping, valves, and fittings including inside vaults and buildings shall be coated as specified in Section 09 96 00 High Performance Coatings. Exposed piping, valves, and fittings to be coated shall be primed by the manufacturer in preparation for coating. Contractor shall provide verification from the finish coating supplier that the field applied coatings are compatible with the manufacturer's prime coat. Pipe to be coated shall not have asphalt emulsion coating.
 - C. Exterior of fittings and pipe within Clearwell or directly concrete encased within Clearwell floor shall have NSF 61 certified coating for ductile iron submerged in potable water per Section 09 96 00 High Performance Coatings.
- 2.12 CEMENT LINING:
- A. Ductile iron pipe and fittings shall be lined with double thickness cement mortar in accordance with the requirements of the AWWA C104 except that the lining thickness shall be not less than 1/8 of an inch. The pipe interior surfaces shall be smooth and free from factures, excessive crazing, and roughness.
 - B. Pipe supplier shall provide cement mortar mix with pipe for field joint repair which shall be NSF 61 certified. As an alternative Hydrakrete-61 by HydraStone may be used for field repairs of joints.

2.13 GASKETS:

- A. Gaskets for push-on type joints or MJ type joints shall be supplied by pipe, fitting, or restraint manufacturer.
- B. Flange gaskets shall be synthetic rubber gaskets for flanged joints in accordance with AWWA C111 and ASME B16.21. Pipe flanges shall be flat faced flanges and gaskets shall be 1/8-inch thick, full faced type. Gaskets shall be Class 250 and shall be Flange-Tyte by U.S. Pipe.

2.14 BOLTS AND NUTS

- A. All flanges, both buried and exposed, shall have stainless steel nuts and bolts as follows: Bolts shall have ASME B1.1, Class 2A threads, and be manufactured of ASTM A193, Grade B8M and conform to ASME B18.2.1, and nuts shall have Class 2A fit, square or hex heavy dimensions in accordance with ASME B18.2.2, and be manufactured of ASTM A194, Grade 8B heavy hex.
- B. Buried bolts and nuts shall be wax tape coated per Section 33 10 00 Water Utilities.

PART 3 - EXECUTION

3.01 HANDLING AND CUTTING:

- A. Mark pipe and fittings "Rejected" and remove from site when cracked or has received a severe blow.
- B. If permitted, cut on sound barrel at a point at least 12 inches from visible limit of crack, at Contractor's expense.
- C. Machine cut with milling type cutters, knives, or saws. Snap cutters, torch, or hammer and chisel NOT ALLOWED. Examine for possible cracks.
- D. Chamfer cut ends if used for push-on joints.

3.02 INSTALLATION:

- A. Visually inspect before installation.
- B. Ensure pipelines parallel to building walls wherever possible. Install piping to accurate lines and grades. Where temporary supports are used, ensure rigidity to prevent shifting or distortion of pipe. Provide for expansion where necessary.
- C. Pitch piping toward low points. Provide for draining low points.
- D. Before assembly, remove dirt and chips from inside pipe and fittings.
- E. Piping Support: Provide in accordance with Section 40 23 19.01.

F. Pipe and Fittings:

1. Remove and replace defective pieces.
2. Clear of all debris and dirt before installing and keep clean until accepted.
3. Lay accurately to lines and grades indicated or required. Provide accurate alignment, both horizontally and vertically.
4. Provide firm bearing along entire length of buried pipelines.

G. Temporary Plugs: When pipe laying not in progress, close open ends of pipe with temporary watertight plugs. If water in trench, do not remove plug until danger of water entering pipe passed.

H. Appurtenances: Set valves, fittings and appurtenances as indicated.

I. Pipelines shall be sealed at the end of every workday to prevent water, dirt, and animal intrusions into the pipe.

J. Pipelines installed for fire service shall be installed per NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

3.03 JOINTS AND COUPLINGS:

A. Push-on Joints:

1. Insert gasket into groove bell. Apply thin film of nontoxic gasket lubricant over inner surface of gasket in contact with spigot end.
2. Insert chamfered end into gasket. Force pipe past it until it seats against socket bottom.

B. Bolted Joints:

1. Remove rust-preventive coatings from machined surfaces.
2. Clean pipe ends, sockets, sleeves, housings, and gaskets and smooth all burrs and other defects.
3. Use torque wrench to tighten to correct range of torque not to exceed values specified below:

Torque Range Values		
Nominal pipe size, in	Bolt diameter, in	Range of torque, ft-lb
3	5/8	40-60
4-24, incl.	3/4	75-90
30, 36	1	100-120
42, 48	1-1/4	120-150

C. FLANGED JOINTS

1. Flange joints shall be assembled per the gasket manufacturer's instructions and as specified herein. Utilize calibrated bolting equipment capable of applying a measured torque to flange bolts during joining. Bolting patterns, procedures, and bolting equipment data shall be submitted prior to pipe fitting and bolting.
2. Gaskets, bolts, and anti-seize lubricant used in the bolting procedure shall be selected from those specified herein. Submit target torque calculations for each application. Calculations shall identify specific gasket (manufacturer, model, size, configuration, material), bolts (size and material), and anti-seize lubricant. The calculations shall document and take into consideration the pipe service, working and test pressures, pipe diameter, gasket data sheet, bolt material, gasket supplier-recommended assembly stress, and gasket-supplier recommended bolt stress. Calculations shall be stamped by a professional engineer. Target torque calculations shall be used in the assembly of bolted joints.
3. Flange bolts, nuts, and washers shall be visually inspected and cleaned prior to bolting. Lubricate bolts and nuts; if hardened washers are not used, lubricate the flange surface around the bolt holes. This lubricant must be removed by cleaning solvent prior to applying a coating system. Hand-tighten all nuts and bolts then tighten them to 10 to 20 percent of the target torque. The initial torque shall not exceed 20 percent of the target torque. The bolts shall be tightened according to the pattern included in AWWA Manual M11, Figure 12-3.
4. For flanges having 4 to 8 bolts there shall be three rounds of tightening, after hand tightening, to 30 percent, 60 percent and then 100 percent of the target torque. For flanges having 12 or more bolts there shall be four rounds of tightening, after hand tightening, to 20 percent, 40 percent, 80 percent and 100 percent of the target torque. At 100 percent of target torque the flange gap shall be measured at every other bolt to confirm uniformity. The bolts shall be re-tightened to the target torque 24 hours after completion of the initial bolting sequence.

D. Mechanical Joints:

1. Wire brush surfaces in contact with gasket and clean gasket.
2. Lubricate gasket, bell, and spigot with soapy water.
3. Slip gland and gasket over spigot and insert spigot into bell until seated.

4. Seat gasket and press gland firmly against gasket.
5. After bolts inserted and nuts made finger-tight, tighten diametrically opposite nuts progressively and uniformly around joint by torque wrench. Torque bolts to values specified above.

3.04 FIELD TESTING:

- A. Contractor shall provide additional temporary blow-off valves and fittings as required to flush and disinfect new pipelines. Temporary blow-off valves and fittings shall be removed prior to placing pipeline into service.
- B. Source of Water: Contractor shall assume all responsibility to obtain the necessary water supplies for pressure testing of the pipeline.
- C. Testing Procedure:
 1. Pipe shall be tested at a static pressure of 225 psi for 2 hours and in accordance with the AWWA C600 standards. Pipe shall be tested in segments such that the test pressure at the low point of the segment shall be 225 psi, and the minimum pressure at the high point in the segment shall be 200 psi.
 2. In the case of pipelines that fail to pass the leakage test, Contractor shall determine the cause of the excessive leakage, shall take corrective measures necessary to repair the leaks, and shall repeat the pipeline test, all at no additional cost to Owner.
 3. Engineer shall be notified at least 48 hours before the pipeline is to be tested so that Engineer may be present during the test.
- D. Pressure and Leak Test
 1. Contractor shall test all piping either in sections or as a unit. The test shall be made by placing temporary bulkheads as needed in the pipe and filling the line slowly with water. Care shall be taken to see that all air vents are open during the filling. Bulkheads, valves, and connections shall be examined for leaks. If any leaks are found, corrective measures satisfactory to Engineer shall be taken. The test shall consist of holding a minimum pressure as shown on the Contract Drawings in the section being tested for a minimum period of two hours using either pneumatic or hydraulic means to maintain the pressure. Suitable means shall be provided by Contractor for determining the quantity of water lost by leakage under the test pressure. The testing allowance is defined as the quantity of water that must be applied to the pipe section being tested to maintain a pressure within 5 psi of the specified hydrostatic test pressure. The maximum allowable leakage shall be defined as follows:

$$L = SD(P)^{1/2}/148,000$$

L = Testing allowance (makeup water) in gallons per hour of test

S = Length of pipe in feet

D = Nominal diameter of pipe in inches

P = Average Test Pressure in pounds per square inch (gauge)

3.05 DISINFECTING AND FLUSHING:

- A. Provide in accordance with Section 33 13 00 Disinfecting of Water Utility Distribution.

3.06 PAINTING

- A. All exposed piping including inside vaults shall be painted as specified in Section 09 96 00 High Performance Coatings.

3.07 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 23 19.05

PROCESS PIPING AND APPUTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide process piping and apprtuenances inside and within 5 feet from buildings and structures. Provide and test process piping and appurtenances as indicated and in compliance with Contract Documents.
- B. Options:
 - 1. For buried exterior pipelines provide push-on joint pipe.
 - a. Provide restrained push-on pipe as specified
 - b. Provide either restrained push-on joint fittings as specified and indicated or provide mechanical joint fittings with restraint system as specified herein
 - 2. For piping exposed as in buildings and galleries, provide flanged or rigid-joint, grooved-coupled pipe and fittings.
 - 3. Cast iron pipe and fittings are not acceptable

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. B1.1: Unified Screw Threads.
 - 2. B16.1: AN Standard for Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800
 - 3. B16.3: Malleable Iron Threaded Fittings Classes 150 and 300
 - 4. B16.5: AN Standard for Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys
 - 5. B16.9: Factory-Made Wrought Buttwelding Fittings
 - 6. B16.15: Standard for Cast Bronze Threaded Fittings, 125 and 250 lb
 - 7. B16.18: Standard for Cast Copper Alloy Solder-Joint Pressure Fittings
 - 8. B16.21: Nonmetallic Flat Gaskets for Pipe Flanges

9. B16.22: Standard for Wrought Copper and Bronze Solder-Joint Pressure Fittings
10. B16.26: Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
11. B16.42: Ductile Iron Pipe Flanges and Flanged Fittings
12. B18.2.2: Square and Hex Nuts.
13. B31.1: Power Piping
14. B31.9: Building Services Piping
15. Boiler and Pressure Vessel Code Section IX.

B. ASTM International (ASTM):

1. A36: Standard Specification for Carbon Structural Steel
2. A47: Standard Specification for Ferritic Malleable Iron Castings
3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
4. A105: Standard Specification for Carbon Steel Forgings for Piping Applications
5. A139: Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)
6. A181: Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
7. A193: Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
8. A194: Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
9. A197: Standard Specification for Cupola Malleable Iron
10. A216: Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
11. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
12. A256: Standard Method of Compression Testing of Cast Iron
13. A269: Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

14. A278: Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (350°C)
15. A307: Standard Specification for Carbon Steel Externally Threaded Standard Fasteners
16. A312: Seamless and Welded Austenic Stainless Steel Pipe
17. A325: Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi minimum Tensile Strength.
18. A351: Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
19. A380: Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment and Systems.
20. A449: Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
21. A530: Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.
22. A536: Ductile Iron Castings
23. A774: Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
24. A778: Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
25. A967: Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
26. B62: Standard Specification for Composition Bronze or Ounce Metal Castings
27. B75: Specification for Seamless Copper Tube
28. B88: Specification for Seamless Copper Water Tube
29. C177: Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
30. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
31. D256: Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
32. D570: Standard Test Method for Water Absorption of Plastics

33. D638: Standard Test Method for Tensile Properties of Plastics
34. D696: Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 Degree C and 30 Degree C with a Vitreous Silica Dilatometer
35. D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
36. D792: Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
37. D1330: Standard Specification for Rubber-Sheet Gaskets
38. D1457: Standard Specification for Polytetrafluoroethylene (PTFE) Molding and Extrusion Materials
39. D1599: Standard Test for Short-Time Rupture Strength of Plastic Pipe, Tubing and Fittings
40. D1784: Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
41. D1785: Standard Specification for Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Plastic Pipe, Schedules 40, 80 and 120
42. D2000: Rubber Products in Automotive Applications
43. D2105: Standard Test for Longitudinal Tensile Properties of Reinforced Thermosetting Plastic Pipe and Tube
44. D2412: Standard Test for External Loading Properties of Plastic Pipe by Parallel-Plate Loading
45. D2467: Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
46. D2564: Standard Specification for Solvent Cements for Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Plastic Pipe and Fittings
47. D2855: Standard Practice for Making Solvent Cemented Joints with Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Pipe and Fittings
48. D2996: Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
49. D3035: Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

50. D3222: Standard Specification for Unmodified Polyvinylidene Fluoride (PVDF) Plastic-Lined Ferrous Metal Pipe and Fittings
51. D3350: Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
52. D5685: Standard Specification for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings
53. E84: Standard Test Method for Surface Burning Characteristics of Building Materials
54. F441: Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
55. F491: Standard Specification for Polyvinylidene Fluoride (PVDF) Plastic-Lined Ferrous Metal Pipe and Fittings
56. F593: Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
57. F1476: Standard Specification for the Performance of Gasketed Mechanical Couplings for Use In Piping Applications.

C. American Welding Society (AWS):

1. B3.0: Welding Procedure and Performance Qualification

D. American Water Works Association (AWWA):

1. A21.4: Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
2. A21.10: Ductile-Iron and Gray-Iron Fittings, 3 in. through 48 in., for Water and Other Liquids.
3. A21.11: Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe Fittings.
4. A21.15: Flanged Ductile-Iron Pipe with Threaded Flanges.
5. A21.50: Thickness Design of Ductile-Iron Pipe.
6. A21.51: Ductile-Iron Pipe, Centrifugally Cast in Metal Molds, or Sand-Lined Molds, for Water or Other Liquids.
7. A21.53: Ductile-Iron Compact Fittings, 3-in through 16-in. for Water and Other Liquids.
8. C105/A21.5: Polyethylene Encasement for Ductile Iron Pipe Systems.
9. C200: Standard for Steel Water Pipe, 6 Inches and Larger.
10. C205: Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4-in. and Larger - Shop Applied.

11. C206: Standard for Field Welding of Steel Water Pipe.
 12. C207: Standard for Steel Pipe Flanges for Waterworks Service, sizes 4 in. through 144 in.
 13. C208: Standard for Dimensions for Steel Water Pipe Fittings.
 14. C209: Standard for Cold Applied Tape Coatings for Special Sections, Connections and Fittings for Steel Water Pipelines.
 15. C210: Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
 16. C213: Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
 17. C214: Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines.
 18. C219: Bolted, Sleeve-Type Couplings for Plain-End Pipe
 19. C222: Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
 20. C602: Standard for Cement-Mortar Lining of Water Pipelines - 4-in. and Larger - In Place.
 21. C604: Installation of Buried Steel Water Pipe – 4 inches (100 mm) and Larger
 22. C606: Grooved and Shouldered Joints
- E. Expansion Joint Manufacturers Association Standards.
- F. Fluid Sealing Association - Technical Handbook.
- G. ISO:
1. 8179-1: Ductile Iron Pipes – External Zinc-Based Coating – Part 1: Metallic zinc with finishing layer. Second Edition 2004-06-01.
- H. Manufacturer's Standardization Society (MSS):
1. SP-67: Butterfly Valves
 2. SP-69: Pipe Hangers and Supports - Selection and Application
- I. Structural Steel Painting Council (SSPC):
1. SSPC-SP10.

1.03 SUBMITTALS:

A. Submit the following in accordance with Section 01 33 00:

1. Pipe manufacturer's technical specification and product data.
2. Submit manufacturer's certificates of conformance.
3. Submit certified copies of test reports.
4. Certified shop and erection drawings. Contractor shall submit electronic files of the piping layout including the following.
 - a. Pipe layouts in full detail.
 - b. Location of hangers and supports.
 - c. Location and type of anchors.
 - d. Location of couplings and expansion joints.
 - e. 1/2-inch = 1 foot-0 inches scale details of all wall penetrations and fabricated fittings or special fittings.
 - f. Schedules of pipe, fittings, special castings, couplings, expansion joints and other appurtenances.
5. Catalog cuts and technical data of joints, couplings, harnesses, expansion joints, gaskets, pipe supports, fasteners and other accessories.
6. Manufacturer's descriptive literature and technical data on insulation and proposed method of installation.
7. Certificates: Sworn certificates in duplicate showing compliance with material used and shop tests performed with appropriate standard.
8. Reports of ASME Section IX welding certifications.
9. Brochures and technical data on coatings and linings and proposed method for application and repair.
10. Provide record drawings.
11. Provide tag names and numbers for all sections of piping and fittings.

B. Grooved joint couplings and fittings: Provide product submittals with products specifically identified by the manufacturer's style or series designation.

1. Manufacturer's descriptive literature and technical data on insulation and proposed method of installation.
2. Shop drawing data for accessory items.
3. Manufacturer's literature as needed to supplement certified data.
4. Operating and maintenance instructions and parts lists.
5. Schematic control and power wiring diagrams.
6. Shop and Field inspections reports.
7. List of recommended spare parts other than those specified.
8. Recommendations for short and long term storage.
9. Special tools.
10. Shop and field testing procedures and equipment to be used.
11. Provide a listing of the materials recommended for each service specified and indicated. Provide documentation showing compatibility with process fluid and service specified and as indicated.
12. The latest ISO 9001 series certification or quality system plan.

C. Material Certification:

1. Provide certification from the piping and equipment manufacturers that the materials of construction specified are recommended and suitable for the service conditions specified and as indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
2. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.

D. A copy of the contract mechanical process, civil, structural, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required".

1. Failure to include all drawings applicable to the equipment specified in this section will result in submittal return without review.

- E. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations and clarifications from the specified requirements.
 - 1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specification and justification are resubmitted with the entire package.

1.04 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 43 00 and as specified.
- B. Provide manufacturer's certification in writing that materials meet or exceed minimum requirements as specified.
- C. Inspect and test at foundry according to applicable standard specifications.
- D. Owner reserves right to inspect and test by independent service at manufacturer's plant or elsewhere at Owner's expense.
- E. Visually inspect before installation.
- F. Welder Qualifications:
 - 1. Qualify and certify welding procedures, welders, and operators in accordance with ASME Section IX for shop welding and AWS D1.1 for project site welding of piping work.
 - 2. Qualification for welders: Welding shall be performed by welders holding current certification for the welding procedures in use.
 - 3. Visually inspect welding while the operators are making the welds and again after the work is completed. After the welding is completed, hand or power wire brush welds and clean them before the inspector makes the check inspection. Inspect welds for defects exceeding tolerances allowed by code under which the weld was made. Repair all defects exceeding tolerance.
- G. Provide all grooved joint couplings, fittings, valves, and specialties to be the products of a single manufacturer. Grooving tools used must be of the same manufacturer as the grooved components.
 - 1. Provide all castings used for coupling housings, fittings, and valve bodies date stamped for quality assurance and traceability.

H. Job Conditions:

1. Coordinate dimensions and drillings of flanges with flanges for valves, pumps, and other equipment to be installed in piping system.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Provide in accordance with Section 01 66 10.
- B. During loading, transportation and unloading, prevent damage to pipes and coatings. Load and unload each pipe under control at all times. Under no circumstances will a dropped pipe be used unless inspected and accepted by Engineer. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to protect pipe, lining, and coating.

PART 2 - PRODUCTS

2.1 ALL PIPES AND FITTINGS:

- A. Provide pipe and fittings with the NSF/ANSI 61 seal of approval for potable water applications as required.

2.2 DUCTILE IRON PIPE AND FITTINGS:

- A. Provide in accordance with Section 40 23 19.04.

2.3 STAINLESS STEEL PIPE AND FITTINGS 2-1/2-INCH AND LARGER:

A. Manufacturers:

1. Douglas Brothers
2. Felker
3. J.F. Ahern
4. Dixie Southern
5. Alaskan Copper and Brass Company
6. Merit Brass

B. Material:

1. Type 316L sheet and plate per ASTM A240.
2. Maximum carbon content of 316L material limited to 0.03 percent.

C. Finish:

1. 2D

D. Fabrication:

1. Fabricate in accordance with ASTM A778 in NPS sizes shown with dimensional tolerances per ASTM A530.
2. Perform welding by qualified welders conforming to standard procedures. Weld piping with wall thickness up to 11 gauge, 0.125-inch, with the TIG (GTAW) process. Properly bevel heavier walls and use a root pass with the TIG (GTAW) process followed by subsequent passes with the TIG (GTAW), MIG (GMAW), or Metallic Arc (SMAW) process.
3. Add filler wire of ELC grades to all welds to provide a cross section at the weld equal to or greater than the parent metal. Distribute smooth and evenly weld deposit and provide a crown of no more than 1/16-inch on the I.D. and 3/32 inch on the O.D. of the piping.
4. Concavity, undercut, cracks or crevices are not acceptable.
5. Butt Welds: Full penetration to the interior surface, with inert gas shielding provided to the interior and exterior of the joint.
6. Remove excessive weld deposits, slag, spatter, and projections by grinding.
7. Continuously weld angle face rings on both sides to the pipe or fitting.
8. Grind all welds on gasket surfaces smooth.
9. Contour pipe branches, taps and bosses to the radius of the main pipe run and bevel and weld with full penetration. No projections to the inside of the branch or main run are acceptable. Provide a smooth transition from ID of run to ID of branch.
10. Wire-brush inside and outside weld areas with brushes of stainless steel that are specifically designed to be used only on stainless steel.
11. After manufacture, passivate stainless steel pipe, fittings, and appurtenances by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid. Temperature and detention time to be sufficient for removal of oxidation and ferrous contamination without more than superficial etch of surface. Perform a complete neutralizing operation by immersion in a trisodium phosphate rinse followed by clean water wash. Perform in accordance with ASTM A380.
12. After fabrication, either passivate by immersion (see above paragraph) or scrub interior and exterior of welds with same solution or pickling paste and stainless steel wire brushes to remove weld discoloration and then neutralize and wash clean. Perform in accordance with ASTM A380.
13. Perform all welding in the shop. Field welding is not acceptable.

- a. If field welding is allowed for certain circumstances, the Contractor shall submit the welders qualifications and an acceptable method of cleaning the pipe and fittings for review prior to start of any field welding.
14. Fittings: Butt weld type manufactured in accordance with ASTM A774 of the same raw material and in the same thicknesses as the pipe. Socket weld fittings are not acceptable.
 - a. Elbows up to 24-inch diameter: Provide smooth flow-die formed, long radius; with centerline to end of elbow equal to 1.5 times the nominal pipe size.
 - b. All short radius, special radius, and reducing elbows and long radius elbows greater than 24-inch diameter: Fabricate with pieces in accordance with the following table with dimensions in accordance with AWWA C208:

Bend, degrees	Number of Pieces
0 to 22.5	2
23 to 45	3
46 to 67.5	4
68 to 90	5

15. Fabricate tees and branch connections true and square with wall thickness same as pipe.
16. Reducers evenly tapered with tangent ends for butt weld connection.
 - a. Reducers may be straight tapered cone construction.
17. Secure flanges to pipe ends and plug openings prior to shipment.

E. Design:

1. Stainless steel pipe: Nominal pipe size diameter pipe fabricated of stainless steel sheets having the following Schedule, U.S.S. gauges and plate thickness:

Nominal Pipe Size inches	Actual O.D. inches	Schedule/Gauge/Plate	Nominal Wall Thickness inches
2.5	2.875	SCH 5S or 10S	0.083
3	3.500	SCH 5S or 10S	0.083
4	4.500	SCH 5S or 10S	0.083
6	6.625	SCH 5S or 10S	0.109
8	8.625	SCH 5S or 10S	0.109
10	10.750	12 Ga. Sheet	0.109
12	12.750	12 Ga. Sheet	0.109
14	14.000	11 Ga. Sheet	0.125
16	16.000	11 Ga. Sheet	0.125
18	18.000	11 Ga. Sheet	0.125

Nominal Pipe Size inches	Actual O.D. inches	Schedule/Gauge/Plate	Nominal Wall Thickness inches
20	20.000	10 Ga. Sheet	0.140
24	24.000	3/16 inch Plate	0.188
28	28.000	3/16 inch Plate	0.188
30	30.000	3/16 inch Plate	0.188
36	36.000	3/16 inch Plate	0.188
42	42.000	1/4 inch Plate	0.250
48	48.000	1/4 inch Plate	0.250
54	54.000	5/16 inch Plate	0.312
60	60.000	5/16 inch Plate	0.312
66	66.000	1/2 inch Plate	0.500
72	72.000	1/2 inch Plate	0.500
84	84.000	1/2 inch Plate	0.500

2. For buried piping use a minimum SCH 10S or as indicated in the Process Piping Schedule.
3. Joints: Flanged or, bolted split sleeve type couplings as indicated and specified. Split couplings requiring cut or roll grooving of the pipe not allowed unless specifically called for.
4. Flanged Joints: Van Stone back-up flange type, ANSI Class 150 lb. (PN10).
5. Provide stainless steel back-up flanges of the grade of pipe specified with the following thickness. Galvanized steel and ductile iron flanges are not acceptable.

Pipe Size, inches	Flange Thickness, inches
2.5, 3 and 4	0.375
6 and 8	0.500
10 to 18	0.750
20 and 24	0.750
28	0.875
30	0.875
36	1.000
40	1.125
42	1.125
48	1.250
54	1.375
60	1.500
66	1.625
72	1.625

6. Hardware: Type 316 stainless steel.

7. Fabricate flanged joint face rings fabricated of rolled stainless steel angles.
8. Use angle face rings with thickness equal to or greater than the wall of the pipe or fitting to which it is welded. Continuously weld on both sides to the pipe or fitting. Fabricate angle legs so as not to interfere with the flange bolt holes.
9. Isolate stainless steel flanges from all other ferrous metal connections at valves, flanges and equipment with flange insulating kit.
 - a. Pipe Flange Insulating Kit:
 - (1) Flange gasket: Type E, 1/8-inch thick NEMA Grade G-10 reinforced epoxy retainer with two seals of the following material:
 - (a) Potable Water: Teflon or EPDM, NSF61 certified.
 - (b) Wastewater and Residuals: Nitrile.
 - (c) Aeration Systems: EPDM.
 - (2) Insulating sleeves: 1/32-inch thick NEMA Grade G-10, full length, one for each flange bolt.
 - (3) Insulating washers: 1/8-inch thick NEMA Grade G-10, two for each flange bolt.
 - (4) Mechanical washers: 1/8-inch thick Type 316 stainless steel, two for each flange bolt.
 - (5) Manufacturers:
 - (a) Trojan Insulating Gasket Advance Products and Systems.
 - (b) Or equal.

2.4 STAINLESS STEEL PIPE AND FITTINGS 1/2-INCH TO 2-INCH:

- A. Provide either Pressfit, grooved or a socket welded system.
 1. Provide a sufficient number of unions for Vic-Press and socket welded systems to allow removal of all valves and inline devices.
 2. Provide threaded connections only where required.
- B. Vic-Press Schedule 10S System:
 1. Vic-Press system, 1/2-inch through 2-inch Schedule 10S comprised of stainless steel Vic-Press fittings, couplings and pipe.

2. Type 316 stainless steel Pressfit couplings and fittings and Type 316 stainless steel Pressfit pipe UL classified to ANSI/NSF 61 for cold +86 degrees F and hot +180 degrees F potable water service.
 - a. Maximum working pressure of 500 psi for water, oil, gas, chemical, air and vacuum services.
3. Couplings, Fittings: Pressfit products formed of Type 316/316L stainless steel tubing including a self-contained o-ring seals molded of synthetic HNBR rubber suitable for water operating temperatures to +210 degrees F.
4. Valves 1/2-inch through 2-inch ball valves with Type 316 stainless steel plain ends for Pressfit assembly. Victaulic Series 569.
 - a. Pressure Rating: 300 PSI.
 - b. CF8M stainless steel body and ball
 - c. Type 316 stainless steel stem
 - d. PTFE seats.
5. Pipe: Type 316/316L ASTM A312 stainless steel
 - a. Schedule 10S.

C. Socket Welded System:

1. Schedule 40 Type 316L stainless steel pipe and fittings with socket welded connections.

D. Grooved System:

1. Schedule 10S type 316L stainless steel pipe and fittings with Type 316 stainless steel grooved end connections and couplings.
2. Fittings: ASTM A403 or be factory fabricated from ASTM A312 stainless steel pipe.
3. Provide couplings consisting of ductile iron or stainless steel housings, with pressure responsive elastomer gasket.
 - a. Rigid Type: Victaulic Style 489 (SS) or equal.
 - b. Flexible Type: Victaulic Style 77S (SS) or equal.
 - c. Installation-Ready, for sizes through 4 inches, with ductile iron housings. Victaulic Style 107H (rigid) and Style 177 (flexible) or equal.
 - d. 14-inch and Larger: AGS Series, with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W89 (rigid) or equal.

2.5 SEAMLESS COPPER TUBE

A. Materials:

1. Pipe, fittings, and solder shall be lead-free and certified to NSF 61 and NSF 372. Letters of conformance to lead-free standards will not be acceptable.
2. Seamless copper water tube ¼-inch to 4-inch diameter shall be furnished in wall thickness Type L (blue marking) or K (green marking), as scheduled or shown on the Drawings, and meet the material and dimensional requirements included in ASTM B88.
3. Seamless Alloy HWT copper water tube, shall have the H58 drawn temper suitable for use with wrought copper soldered-joint, brazing cup fittings, pressfit and grooved-joint fittings. This tube shall be furnished in straight lengths and shall not be installed by bending.
4. Seamless Alloy OWT copper water tube shall be furnished in rolls, or straight-lengths and have the O50 light-annealed temper for use with wrought solder-joint, brazed, flared and compression fittings.

B. Fittings:

1. Cast copper soldered (sweat)-joint fittings for copper tube shall be manufactured in accordance with ASME B16.18. Cast fittings shall be manufactured of the same material as the connecting pipe.

C. Solder:

1. Alloy Sn96 solder shall be 96 percent Tin and 4 percent Silver and lead free. Alloy Sn96 shall meet all of the requirements of the latest revision of the US-EPA Safe Drinking Water Act. Alloy Sn96 solder shall be used with lead free tinning flux paste containing 95 percent Tin/5 percent Antimony solder powder. The flux shall be approved for use with Sb5 solder metal alloy specified herein. The temperature range for this flux shall be 400 to 700 degrees F. Flux and solder shall be NSF 61 and 372 certified.

2.6 SEAMLESS RED BRASS PIPE

A. Materials:

1. Pipe, fittings, and solder shall be lead-free and certified to NSF 61 and NSF 372. Letters of conformance to lead-free standards will not be acceptable.
2. Seamless Alloy 230 red brass pipe, ¼- to 4-inch diameter, Class 125 (strong) and Class 250 (extra-strong), shall meet the dimensions, weight and tolerances included in ASTM B43. Seamless Alloy 230 pipe shall be furnished in the O61 annealed temper.
3. Pipe shall be furnished in straight lengths, suitable for threading and use with cast bronze threaded fittings. Threaded ends of nipples shall be in conformance with ASME B1.20.1.

4. Threaded nipples shall conform to ASME B1.20.1.

B. Fittings:

1. Cast Threaded Joint Fittings: Cast bronze per ASTM B62, ASME B16.15. Threads adhering to ASME B1.20.1.
2. Unions: Brass bodies per ASTM B16

2.7 CPVC PIPE AND FITTINGS:

A. Schedule 80.

B. Material: Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a Cell Classification of 23447 per ASTM D1784.

C. Provide pipe and fittings manufactured in compliance to ASTM F441 meeting the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality.

D. Provide pipe and fittings produced in the USA using domestic materials, by an ISO 9002 certified manufacturer, and shall be stored indoors after production, at the manufacturing site, until shipped from factory.

E. Joining:

1. Solvent cementing process.
2. Use only Weld-On 724 for all sodium hypochlorite services.
3. Provide flanges at valves pumps and equipment only or as indicated and specified.
4. Threaded connections are not acceptable.
5. Provide Type 316 stainless steel flange bolting and hardware for all piping system except sodium hypochlorite use titanium.

2.8 PVC PIPE AND FITTINGS:

A. Schedule 80

B. Material: Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784.

C. Provide pipe and fittings manufactured in compliance to ASTM D1785 meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality.

- D. Provide pipe and fittings manufactured in the USA, using domestic materials, by an ISO 9002 certified manufacturer. Store all pipe shall be stored indoors after production at the manufacturing site until shipped from factory.
- E. Provide standard lengths of pipe sizes 10-inch and larger beveled each end by the pipe manufacturer.
- F. Joining:
 - 1. Solvent cementing process.
 - 2. Provide flanges at valves, pumps and equipment only or as indicated and specified.
 - 3. Provide Type 316 stainless steel flange bolting and hardware for all piping system except sodium hypochlorite use titanium.

2.9 PVC CLEAR PIPE AND FITTINGS:

- A. Schedule 80 Clear pipe
- B. Material: Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784.
- C. Provide pipe and fittings manufactured in compliance to ASTM D1785, consistently meeting and/or exceeding the applicable Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality.
- D. Provide pipe and fittings manufactured in the USA by an ISO 9002 certified manufacturer.
- E. Provide all Clear PVC pipe and fittings packaged immediately after its manufacture to prevent damage, and stored indoors at the manufacturing site until shipped from factory.
- F. Joining:
 - 1. Solvent cementing process. Use a clear, medium-bodied, fast-setting cement in conjunction with a clear primer for optimum joint integrity, such as IPS Weld-on 705 Clear cement and IPS Weld-On P-70 Clear primer or acceptable equivalent product.
 - 2. Clear female threaded transition fittings, incorporating a Type 316 stainless steel retaining ring. Provide all threaded joints with three wraps of tape in the direction of the threads on the male end, followed by one to two turns beyond finger tight.
 - 3. Standard rigid thermoplastic pipe fittings with flanges, molded grooved coupling adapters and unions.
 - 4. Provide Type 316 stainless steel flange bolting and hardware for all piping system except sodium hypochlorite use titanium.

2.10 STEEL PIPE AND FITTINGS 10-INCH AND SMALLER:

- A. Materials: Carbon steel, ASTM A53, Schedule 40, 80 or 120 black or galvanized as indicated in the Process Piping Schedule.
- B. Joints:
 - 1. Pipe 2-1/2 inch and smaller: Screwed joints using malleable-iron fittings, black or galvanized, to match pipe.
 - 2. Pipe 3-inch and larger: Welded joints and butt-weld steel fittings.
 - 3. Pipe 2-inch and larger: Grooved joints and fittings.
 - 4. Provide flanged connections to equipment and valves with 150-lb. (Class 150) weld neck flat faced flanges.
 - 5. Welding of pipe within classified areas in operation is not acceptable. Provide shop fabricated sub-assemblies and install with flanges or grooved-couplings as specified and indicated.
- C. Fittings:
 - 1. 2-1/2-inch and smaller: Screwed type, 150-lb. (Class 150) malleable iron, black or galvanized to match the pipe, ASTM A197 or A47, conforming to ASME B16.3. Unions of 150-lb. (Class 150) malleable iron with brass to iron seat.
 - 2. 3-inch and larger: Butt welded carbon steel to match pipe wall thickness, ASTM A234, conforming to ASME B16.9 standards.
 - 3. 2-inch and larger: Grooved end fittings; Ductile iron ASTM A536 Grade 65-45-12; Wrought steel ASTM A234 Grade WPB; or Factory-fabricated from steel pipe conforming to ASTM A53.
- D. Grooved Joint Couplings: Provide couplings consisting of two ductile iron housing segments to ASTM A536, pressure responsive gasket to ASTM D2000, and Type 316 stainless steel bolts and nuts. Provide couplings complying with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use In Piping Applications.
 - 1. Rigid Type: Provide coupling housings cast with offsetting angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ASME B31.1 and B31.9 or equal.
 - a. Victaulic Style 107H, Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 degrees F.
 - b. Victaulic Style 07 "Zero-Flex" or equal

2. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77 or equal.
3. 14-inch and Larger: AGS Series, with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible) or equal.

E. Branch Connections:

1. 2-inch and smaller connections to welded pipe: Screwed, forged carbon steel, ASTM A105, 3,000-lb. half-couplings or welding saddle with threaded outlet.
2. 2-1/2-inch and larger pipe connections: Tees or reducing tees. Butt welded carbon steel to match pipe wall thickness, ASTM A181 GR1 or A105 GR1, conforming to ASME B16.1 standards.

F. Flanges: Forged steel, ASTM A181.

1. Slip-on or welding neck type as specified and indicated.
2. Provide 150-lb. (Class 150) flanges drilled and faced.
3. Raised face type: 1/16-inch raised faced in accordance with ASME B16.5.
4. Flat-face, welding neck type: ASME B16.1 Standard for all connections to valves and equipment.
5. Gaskets: For flanged joints, 1/16 inch thick suitable for the service specified and indicated.
6. Flange Adapters: Flat face, ductile iron housing with elastomer pressure responsive gasket, suitable for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741 / W741 or equal.

2.11 STEEL PIPE AND FITTINGS 12-INCH AND LARGER:

1. Provide in accordance with Section 40 23 19.03.

2.12 HDPE PIPE AND FITTINGS:

A. Manufacturers:

1. Independent Pipe Products
2. JM Eagle
3. WL Plastics
4. Performance Pipe

B. Provide iron pipe size high density polyethylene pipe and fittings.

1. Size range: 4-inch to 42-inch.
2. Working Pressure: 50 psi.
3. DR: see schedule
4. Joints:
 - a. Butt heat fusion.
 - b. Flanged: Provide at all equipment, valves, tanks and wall penetrations.
5. Flanged Connections: Van Stone type with HDPE flange and bolt ring as specified.
 - a. Bolt Torque: Install in accordance with Plastic Pipe Institute, Inc Technical Note #38.
6. Fittings:
 - a. 90 Degree Bends: Provide 5 piece HDPE segmented elbows.
 - b. 45 Degree Bends: Provide 3 piece HDPE segmented elbows.
 - c. Concentric Reducers: HDPE three section traditional type design, compact reducers are not acceptable.
 - d. For pump suction eccentric reducers provide flanged glass lined ductile iron or flanged Type 316L stainless steel as indicated.
 - e. Provide stiffeners where required.

C. Materials:

1. Pipe and Fittings: Material designation PE4710 in accordance with ASTM D3035 or PE3048 in accordance with ASTM D3350.
2. Bolt Rings: Type 316 stainless steel ASTM A531 Grade CF8M.
3. Hardware: Type 316 stainless steel.

2.13 CHEMICAL TUBING AND FITTINGS – BRAIDED PVC:

A. Manufacturers:

1. Accuflex
2. Dura-Pure

B. Tubing:

1. Provide braided reinforced flexible PVC tubing resistant to the chemical specified.
2. Tubing to allow tight compression fittings for leak proof connections.
3. Tubing to comply with FDA standards.
4. Tubing to handle a maximum of 130 psi at 70 degrees F.

C. Fittings:

1. Provide no flow restriction compression fittings when connecting pieces is required.
2. Provide transition connections as detailed on the drawings.

2.14 CHEMICAL TUBING – POLYETHYLENE TUBING:

A. Construction:

1. Provide polyethylene tubing resistant to the chemical specified in accordance with AWWA C901. Provide hoses that are suitable for suction and discharge applications.
2. Tubing to allow tight compression fittings for leak proof connections.
3. All tubing and fittings shall be designed for a working pressure of 150 psi at 70 degrees F.
4. All tubing and accessories shall be new materials in first-class condition. Used or recycled materials will not be allowed, regardless of condition.
5. Tubing shall include markings for manufacturer and trademark, manufacturing data code, nominal size and DR ratio, pressure class and certifications.

B. Fittings:

1. Parker Fast Tite, or approved equal
2. Provide no flow restriction compression fittings when connecting pieces is required.
3. Provide transition connections as detailed on the drawings.

C. Leak Detection:

1. For double contained pipe, provide above ground leak detection stations as indicated on drawings or as specified. At a minimum provide one leak detection station at each piping low point. Slope pipe to leak detection stations.

D. Materials:

1. Tube: Type T (FEP) Teflon with crosslinked polyethylene backing.
2. Reinforcement: Synthetic textile with steel helix.
3. Cover: EPDM.

E. Sizes:

1. 3/4-inch through 2 inch: 200 psi.
2. 2.5 and 3 inch: 150 psi.
3. 4 inch 125 psi.
4. 3/4 inch through 4 inch: 30 in Hg vacuum.

F. Coupling: Provide type and materials as recommended by the hose manufacturer for the service conditions specified and indicated.

1. For sodium hypochlorite provide flanged connection.

2.15 CHEMICAL DIFFUSERS:

- A. 2-inch Schedule 80 PVC, in accordance with Paragraph 2.06.
- B. 5/16-inch diameter holes at 9-inch on center. Refer to drawings for construction.

2.16 PRESSURE GAUGES:

A. Gauges:

1. Non-liquid filled type.
2. Helical wound bourdon tube, Inconel X-750.
3. Welded parts: Type 316 stainless steel.
4. Bearings: Precision Sapphire Type.
5. 1/2-inch NPT bottom male thread connection.
6. Accuracy: 1/2 percent of scale range.
7. 4-1/2-inch diameter with ABS plastic case.
8. Provide external adjustment.
9. Pipe and Fittings: Schedule 5 Pressfit or Schedule 40 threaded or socket welded, Type 316L stainless steel.

10. Pump Suction Gauges: Provide gauges with range to cover both the normal operating range and the range of pressures that will result from flushing.
 11. Pump Discharge Gauges: Provide gauges with range to cover the normal operating range, above the pump shutoff head and the range of pressures that will result from flushing.
 12. Seal Water Gauges: Provide gauges with range to cover both the normal operating range and the range of pressures that will result from flushing.
 13. Double Wall Stainless Steel Expansion Joint Gauges: Provide gauges with ranges to suit process line pressure as specified and indicated for the service specified in the Process Piping Schedule.
- B. Pipe and fittings: Type 316L stainless steel, provide as specified herein.
- C. Ball valves: General service stainless steel ball valves in accordance with Section 40 23 13.01.
- D. Pressure Sensor Rings:
1. 1-inch and Larger: Provide sensor/isolators that fit inside the bolt circle of 150-lb (Class 150) or 300-lb (Class 300) ANSI flanges as required.
 2. 3/4-inch and Smaller: Provide sensor/isolators full flange or threaded as specified and indicated. For chemical system provide full flange, threaded connections are not acceptable.
 3. Face to face length of the sensor: Conform to Specification MSS-SP67.
 4. Type: Flow through design with flexible sleeve around full circumference. The center section shall have a cavity behind the sleeve filled with silicone fluid to transfer pressure to the gauge.
 5. Rigidly support all pressure instruments by a post at least 7/8 inch diameter welded to the isolator. On sensor rings with more than one instrument, provide all connections 1/2-inch NPT as a minimum, 1/4-inch NPT fittings are not acceptable.
 6. Provide sensor/isolator rings that do not have any fill plugs or valves that can be inadvertently removed with the resultant loss of fill fluid. Pressure sensor/isolators using valves are not acceptable.
 7. Provide liquid filled sensor/isolators permanently vacuum sealed at the factory with a modular seal consisting of a membrane and needle fitting to allow removal and replacement of pressure instruments without compromising the vacuum fill. Sensor/isolators using valves are not acceptable.
 8. Provide the needle fitting with both 1/4-inch NPT(F) threads and 1/2-inch NPT(M) threads.

9. Provide the pressure sensor/isolator capable of operating under pressure with all pressure instruments removed with no loss of fill fluid. Provide an intergral block valve, separate isolation valves are not acceptable.
10. Attach pressure instruments to the isolator with a hand tightened lock ring.
11. It shall be possible to remove or attach pressure instruments to the isolator without requiring the use of any tools.
12. Permanently fill the pressure sensor with high viscosity silicone instrument oil to damp out surges or pressure spikes without the requirement for a separate snubber.
13. Pressure rating: 200 psi minimum for all lines tested at 150 psi or less and 600 psi minimum per lines tested above 150 psi.
14. Provide gauges as specified herein. Provide all other types of instruments indicated and specified in accordance with Section 40 90 00.
15. Materials:
 - a. Pressure sensor/isolator rings: Provide materials suitable for the service conditions specified and indicated, as a minimum provide the following

Service	Body & Plates	Sleeve
Water	Type 316L Stainless Steel	Natural Rubber
Wastewater	Type 316L Stainless Steel	Natural Rubber
Sludge	Type 316L Stainless Steel	Natural Rubber
Scum	Type 316L Stainless Steel	Natural Rubber
Septage	Type 316L Stainless Steel	Natural Rubber
Grit	Type 316L Stainless Steel	Natural Rubber
Sodium Hypochlorite	Titanium	EPDM
Sodium Bisulfite	Type 316L Stainless Steel	EPDM
Sodium Hydroxide	Type 316L Stainless Steel	EPDM
Ferric Chloride	Kynar Coated Steel	EPDM
Potassium Permanganate	Type 316L Stainless Steel	Natural Rubber
Lime	Type 316L Stainless Steel	Natural Rubber
Polymer	Type 316L Stainless Steel	Viton
Bioxide	Type 316L Stainless Steel	Buna-N
Methanol	Type 316L, Stainless Steel	Viton Type F

2.17 PRESSURE AND FLOW INSTRUMENTATION:

- A. Provide Pressure Instrumentation in accordance with Section 40 73 00.
- B. Provide Flow Instrumentation in accordance with Section 40 71 00.

2.18 WATER PRESSURE REGULATORS 1/2-INCH THROUGH 1-INCH:

- A. Provide in accordance with Section 40 23 13.01.

2.19 COUPLINGS-SLEEVE TYPE:

- A. Manufacturers:

- 1. Romac
- 2. Smith Blair
- 3. Viking Johnson
- 4. Dresser

- B. Provide couplings meeting AWWA C219

- C. Couplings 12-inch and smaller:

- 1. End rings and center rings: ASTM A536 ductile iron, fusion bonded epoxy coated
- 2. Gaskets: Buna-N, NSF/ANSI 61 approved
- 3. Hardware: Type 316 stainless steel

- D. Couplings 14-inch (350 mm) and larger:

- 1. End rings and center rings: ASTM A36 steel, fusion bonded epoxy coated
- 2. Gaskets: Buna-N, NSF/ANSI 61 approved
- 3. Hardware: Type 316 stainless steel

- E. Bridles and tierods: Minimum 3/4-inch diameter, except where tierods replace flange bolts of smaller size, in which case fit with nut on each side of pair of flanges.

- 1. Provide as indicated

- F. Provide middle ring of each mechanical coupling with a thickness at least equal to that specified for size of pipe on which coupling is to be used and not less than 10 inch long for pipe 30 inch and larger and not less than 7 inch long for pipe under 30 inch in diameter.

- 1. Omit pipe stop from inner surface of middle rings of couplings to permit removal of valves, flow meters, and other installed equipment.
- 2. Provide pipe stops in other couplings.

- G. Provide cleaning and shop priming with manufacturer's standard rust inhibitive primer.

H. Where noted or indicated, provide mechanically coupled steel pipe joints anchored to steel pipe with harness bolts. Weld harness lugs to steel pipe prior to application of lining.

1. Joint harness bolts: Provide harness lugs placed and provide harness bolts of length such that coupling can be slipped at least in one direction to clear joint. Provide harnesses designed per AWWA M11 to withstand test pressure indicated in Process Pipe Schedule.

2.20 COUPLINGS-BOLTED SPLIT SLEEVE TYPE:

A. Manufacturers:

1. Victaulic Depend-O-Lok

B. Type: Bolted, split-sleeve type coupling consisting of four basic components; one piece housing, gaskets assembly, bolts and nuts, and restraint rings as required for restraint.

1. Provide split-sleeve with a double arch cross section closing around pipe ends that are smooth for expansion or contraction requirements or pipe ends with end rings affixed for pipe end restraint requirements. As the coupling housing closes, it confines the elastomeric gasket beneath the arches of the sleeve to create the radial seal. The axial seal is affected by the sealing plate at the closure plates as the bolts pull the coupling housing snug around the pipe.
2. Provide sealing members comprised of two "O" ring gaskets and an elastomer sealing pad bonded to the integral sealing plate.

C. Provide couplings designed for the type, size, and working pressure of the piping system as indicated in the Process Piping Schedule and specified.

D. Materials:

1. Split-sleeve:

- a. Carbon Steel and Ductile Iron pipelines: ASTM A36 Carbon Steel.
- b. Stainless steel pipelines, ASTM A240 Type 316L stainless steel.
- c. Provide stainless steel couplings where there is a transition for ductile iron to stainless steel piping.

2. Gaskets:

- a. Material: Elastomers in accordance with ASTM D2000.
 - (1) Air Service: Silicone conforming to ASTM D2000 for air service up to 240 degrees F with intermittent exposure to 280 degrees F.
 - (2) Liquid Service: Isoprene or Buna-N conforming to ASTM D2000 for service within the temperature range of -20 degrees F to 180 degrees F.

3. Bolts and Nuts:
 - a. Bolts: Stainless steel conforming to ASTM F593 Type 316, minimum tensile strength 85,000 psi, (or threaded studs to ASTM A193, Class 2 Grade B8M Type 316)
 - b. Nuts: ASTM F593 Type 316.
4. End Restraint Rings:
 - a. Provide restraint rings of the same material as the coupling housing.
 - b. Non-restrained (ExE) type couplings allows for up to 4 degree deflection. Provides for coupling joint where restraint is not required. If restraint is required, it must be provided independent of the coupling.
 - c. Fixed x Expansion (FxE) type couplings: Allows for thermal expansion and contraction at the pipe joint. Provide one or two restraint rings fixed to one end of the pipe to keep coupling in the proper location. Where split sleeve coupling FxE for expansion is used provide the expansion side of the coupling with a combination of fixed and sliding supports for thermal movement.
 - d. Fixed x Fixed (FxF) type couplings: Provides a fully restrained pipe joint. Provide one restraint ring welded to each of the pipe ends fitting beneath the coupling to prevent the pipe joint from pulling apart.
 - e. Provide type as indicated and specified.
 - f. Follow manufacturer's written recommendations and instructions for location dimensions and welding detail required to attach the restraint rings.
- E. Provide a Type 316 stainless steel nameplate welded to each coupling with the following data:
 1. Manufacturer and date fabricated.
 2. Type of Coupling (ExE, FxE, FxF).
 3. Working Pressure in psi.
 4. Test Pressure in psi.
 5. Materials for coupling, hardware and gaskets.
- F. Protective Coating: Prior to installation, couplings shall be coated on the I.D. and O.D. in accordance with Section 09 96 00.
- G. Couplings installed underground: Provide bitumastic coating or joint tape wrap.
- H. Installation of couplings shall be in accordance with manufacturer's recommendation.

1. The coupling housing shall be assembled pulling the closure plates together with the bolts tightened to assure snug coupling housing contact with the pipe OD. Follow the manufacturer's recommendation regarding the installation and tightening of the bolts.

2.21 EXPANSION JOINTS-ELASTOMERIC FLEXIBLE CONNECTION:

- A. General: Provide flexible connectors as indicated, specified and as required for ductile iron, HDPE, steel and stainless steel piping

1. At equipment connection: To eliminate vibration and stress on equipment.
2. Elsewhere: Designed for expansion/contraction.
 - a. Hot Water Systems: 1.25 inch per 100 feet.
 - b. All other Piping Systems: 0.5 inch per 100 feet.

- B. Manufacturers:

1. Mercer Rubber Co.
2. General Rubber Co.
3. Garlock, Inc.
4. Proco.

- C. Products:

1. Straight-through or tapered design as required.
2. Filled arch type for wastewater, sludge and scum applications
3. Furnish control rods for test pressures as indicated or required.
4. Materials: Suitable for service specified and indicated.
5. At expansion joints, provide guide supports located per manufacturer's recommendations.
6. Flanges: 125 lb (Class 125) drilling.
7. Provide Type 316 stainless steel retaining rings.

- D. Install joints in their neutral position.

2.22 EXPANSION JOINTS-STAINLESS STEEL:

- A. Manufacturers:

1. Pathway
2. Flexonic
3. Adsko
4. Victaulic Omni-Flex

B. Design Criteria:

1. Liquid: Service as indicated in the Process Pump Schedule.
2. Liquid Temperature: As indicated in the Process Pump Schedule.
3. Minimum Pressure Rating: 150 psi minimum or as indicated in the Process Piping Schedule.
4. Minimum Lateral Movement: 0.125-inch.
5. Minimum Axial Movement: 0.4-inch.
6. For expansion joints used on pump discharge nozzles the Contractor shall coordinate the rod size and movement allowable with the pump manufacturer and provide a statement from the pump manufacturer that the expansion joint and rod size is acceptable for the pump provided.

C. Products:

1. Provide bellows of two ply construction formed from concentric tubes having only longitudinal seams.
2. For two ply construction, each ply shall be capable of retaining the rated pressure at the specified temperature independently.
3. For two ply construction, seal weld both plies so that no gas or liquid leaks out at the ends.
4. For two-ply construction, provide a pressure monitoring connection with pressure gauge and pressure switch as specified herein for the annular space.
5. Provide control rods for test pressure.
6. Provide minimum two lifting lugs on each joint. Each lug shall be designed to carry the entire weight of the assembly.
7. Provide each joint with a liner and mark a flow arrow on the outside to indicate direction of flow.

8. Provide each expansion joint with a Type 316 stainless steel nameplate indicating size, bellows material, pressure and temperature rating, lateral and axial limits on movement, date of manufacturer, and the manufacturer.

D. Materials:

1. Bellows:
 - a. Inner Ply: Inconel alloy 625, minimum 0.048-inch thick.
 - b. Outer Ply: Inconel alloy 625, minimum 0.048-inch thick.
 - c. Fully annealed stainless steel, Type 316 or 321; to ASTM A240.
2. Liner: Type 316L stainless steel, minimum 0.1875-inch thick.
3. Flanges: Type 316L stainless steel, Class 150.
4. End Preparation: Stainless steel; suitable for installation with Victaulic Depend-O-Lok couplings.
5. Limit Rods/Nuts and Hardware: Type 316 stainless steel.

E. Install joints in their neutral position.

2.23 EXPANSION JOINTS-CHEMICAL SERVICE:

A. Service Conditions:

1. 12.5% sodium hypochlorite solution.
 - a. Temperature: 70 degrees F.
 - b. pH: 11 to 13.5.
2. 50% citric acid solution.
 - a. Temperature: 70 degrees F
 - b. pH: 1.7
3. 38% Sodium Bisulfite solution
 - a. Temperature: 70 degrees F
 - b. pH: 3.8 to 5.2
4. 40% aluminum chlorohydrate solution

- a. Temperature: 70 degrees F
 - b. pH: 3.5 to 4.5
- 5. Working Pressure: 150 psi.
- 6. Mating Pipe: SCH 80 CPVC, SCH 80 PVC, Kynar lined steel, titanium or stainless steel as indicated in the Process Piping Schedule.
- B. Type: Bellows
 - 1. Capable of angular, parallel and rotary misalignment at maximum extended and minimum retracted length when mechanically limited by restraints.
 - 2. Joints, as specified, must be manufacturer's standard cataloged product.
- C. Materials:
 - 1. Convolute Components: Pure white virgin PTFE-Fluorocarbon resin conforming to ASTM D1457 without pigments, lubricants or additives of any kind and suitable for the service specified. Provide a written recommendation from the expansion joint manufacturer.
 - a. Wall thickness: Suitable for the service specified or indicated and as recommended by the joint manufacturer.
 - 2. Reinforcing rings:
 - a. Type 316 stainless steel for caustic service.
 - b. Titanium or Kynar coated for sodium hypochlorite service.
 - 3. Flanges: Drilled and tapped to 150-lb ANSI (Class 150) standard.
 - a. Type 316 stainless steel for caustic service.
 - b. Titanium or Kynar coated for sodium hypochlorite service.
 - 4. Hardware:
 - a. Type 316 stainless steel for caustic service.
 - b. Titanium for sodium hypochlorite service.
- D. Joint Testing:
 - 1. Leak free after 100,000 cycles at maximum rated travel 10 cycles per minute at 70 degrees F.

2. Test at 75 psi.
3. Provide high intensity light test to detect any imperfections or inclusions.
4. Provide a 10,000 volt spark test, no arcing is acceptable.

2.24 SAFETY SHIELDS-CHEMICAL SERVICE:

- A. Provide shield type and materials for the service specified. Provide a written recommendation from the safety shield manufacturer.
- B. Material: Non-porous teflon-impregnated glass cloth with a 5 mil thickness and sewn with 100 percent teflon thread and velcor closures and folded in a trifold design with an 0.82 mil teflon cord inserted on the sides to act as a draw string tying on the flange neck. Provide for use with 150 lb ANSI flanges.
- C. Draw string or cord: 100 percent virgin unbleached teflon fiber.
- D. Provide a clear leak indicating window with a pH paper insert that will change color to indicate a leak.
- E. Provide shields with a working temperature rating of 200 degrees F and a working pressure rating of 200 psi.
- F. Install safety shield for the following:
 1. Expansion joints chemical services.
 2. Flanged connections on chemical system pipe and fittings.

2.25 FLOW RATE INDICATORS:

- A. Type: Rotometer with integral flow control valve.
- B. Materials:
 1. Polysulfone body with threaded ends,
 2. Type 316 stainless steel float and guide.
- C. Calibrate in gpm.
- D. Accuracy +2 percent of full scale reading over 10:1 range.
- E. Capacities as indicated. For pump seal water services provide with range as recommended by the pumping equipment manufacturer.
- F. Working Pressure Rating: 150 psi.

2.26 HOSE, HOSE FITTINGS AND ACCESSORIES:

A. Hose Manufacturers:

1. Goodrich, HPD Industries
2. Goodyear
3. United Rubber Supply
4. Goodall

B. Hose: 1-inch:

1. Provide 4-ply rubber-lined and rubber-covered water hose for 150 psi working pressure.
2. Nozzle:
 - a. Shatter proof and UV resistant Lexan constant flow nozzle with bumper.

C. Hose Reels:

1. Type 316 stainless steel, mill finish.
2. Heavy duty square tubing frame.
3. Spring rewind with declutching arbor.
4. Stainless steel ball bearing swivel joint.
5. 1-inch female NPT.
6. 50 feet of hose.
7. Provide a flexible connector between the inlet pipe and inlet swivel joint.
8. Manufacturer: Hannay Model SS800 or acceptable equivalent product.

2.27 Y-PATTERN STRAINERS-CLEAR NON METALLIC:

A. Sizes: 1/2-inch through 2-inch

B. Materials:

1. Body and Cap: Clear Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784.
2. Seals: Viton
3. Screen: PVC with 1/32-inch perforations

- C. Ends: Socket
- D. Pressure Rating: 150 psi at 70 degrees F.

2.28 BASKET STRAINERS-CHEMICAL SERVICE:

- A. Service Conditions:
 - 1. Provide strainers suitable for the chemical service as indicated in the equipment schedules.
 - 2. Provide size and type, simplex and duplex, as indicated.
- B. Materials:
 - 1. Body and Cover: CPVC
 - 2. Valves for duplex strainers: CPVC
 - 3. O-rings: EPDM or suitable for the service specified and indicated.
 - 4. Baskets: CPVC with 1/16-inch perforations
- C. Covers: Threaded with hand operable vent.
- D. Body:
 - 1. Provide with and operable drain.
- E. Provide with integral flat mounting base.
- F. Ball Valves for duplex strainers: Provide a 3-way ball valve at the inlet and outlet, mechanically connected with true-union connections.
- G. Pressure Rating: 150 psi.
- H. End Connections: Flanged 150 psi ANSI (Class 150) standard.
- I. Duplex Strainer Configuration: Provide configuration as indicated.

2.29 INLINE SELF-CLEANING STRAINERS:

- A. Type: Peripheral inflow design, self cleaning with cylindrical straining screens.
- B. Straining Screens:
 - 1. Media Type:
 - a. Wedge-Wire; Type and size as indicated in Contract Documents.

2. Material: Type 316 stainless steel.
3. Provide rigid scraper bars mounted adjacent to the screens.

C. Strainer Body: Cast Iron ASTM A278 Class 30:

1. Provide body with inline inlet and outlet, flanged, 150-lb (Class 150).
2. Provide factory hydrostatic testing of body at 150 percent of the maximum working pressure of the strainer.
3. Provide rigid scraper bars mounted adjacent to the screens.
4. Provide an inspection port and cover for access to the scraper bars for inspection and adjustment without disassembly or removal the strainer from the pipeline.
5. Provide a sump for solids removed from the flow stream.
6. Reject Valves:
 - a. Provide a 120 Volt, 60 Hertz, NEMA 4X electric motor operated ball valve operated by the control logic to flush solids from the strainer during the cleaning sequence.
 - b. Provide valves in accordance with Section 40 23 13.01.
 - c. Provide valve actuators in accordance with Section 40 23 13.03.

D. Motors:

1. Provide in accordance with Section 26 20 00 and as specified.
2. Service Factor: 1.15.
3. Insulation: Class F.

E. Provide a differential pressure device for strainer backwash control.

2.30 WALL AND FLOOR SLEEVES:

A. Materials:

1. Schedule 40 Type 316L stainless steel with 2-inch waterstop welded both sides to prevent thrust movement and provide positive water sealing.
2. Schedule 40 carbon steel with 2-inch waterstop welded both sides to prevent thrust movement and provide positive water sealing. Model GPWSW manufactured by Advance Products & Systems, Inc., or Equal

3. HDPE, 2-inch thru 24-inch and only where indicated and specified.
- B. Water Stops: Provide waterstops welded on both sides. Provide waterstops 1/4-inch thick and 2-inch high and centered on the wall thickness.
- C. Provide modular, mechanical type seals, consisting of inter-locking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening.
 1. Manufacturer:
 - a. APS (Innerlynx)
 - b. CCI Piping Systems
 - c. Or equal.
- D. Provide the elastomeric elements sized and selected per manufacturer's recommendations and have the following properties as designated by ASTM. Coloration shall be throughout elastomer for positive field inspection. Each link shall have a permanent identification of the size and manufacturer's name molded into it.
- E. Temperature Range: -40 to +250 degrees F.
 1. Material: EPDM, ATSM D2000 M3 BA510
 2. Color: Black
- F. Modular seal pressure plates: Molded of glass reinforced Nylon Polymer with the following properties:
 1. Izod Impact – Notched: 2.05ft-lb/in. per ASTM D256
 2. Flexural Strength @ Yield: 30,750 psi per ASTM D790
 3. Flexural Modulus: 1,124,000 psi per ASTM D790
 4. Elongation Break: 11.07 percent per ASTM D638
 5. Specific Gravity: 1.38 per ASTM D792
- G. Hardware: Type 316 stainless steel.
- H. Pipe Flange Insulating Kit:
 1. Flange gasket: Type E, 1/8-inch thick NEMA Grade G-10 reinforced epoxy retainer with two seals of the following material:
 - a. Potable Water: Teflon or EPDM, NSF61 certified.

- b. Insulating sleeves: 1/32-inch thick NEMA Grade G-10, full length, one for each flange bolt.
 - c. Insulating washers: 1/8-inch thick NEMA Grade G-10, two for each flange bolt.
 - d. Mechanical washers: 1/8-inch thick Type 316 stainless steel, two for each flange bolt.
- 2. Manufacturers:
 - a. Trojan Insulating Gasket Advance Products and Systems.
 - b. Or equal.

2.31 TRANSITION COUPLINGS:

- A. Provide coupling in accordance with AWWA C219 as specified herein
- B. Sizes: 2-inch through 24-inch.
- C. Materials:
 - 1. End rings and center rings: Ductile iron ASTM A536.
 - 2. Gaskets: Virgin Styrene Butadiene Rubber (SBR) suitable for potable water and wastewater service, ASTM D2000 MBA 710.
 - 3. Provide 5/8-inch, Type 316 Stainless steel bolts and nuts
- D. Working Pressure: 250 psi.
- E. Lining and Coating: Fusion bonded epoxy in accordance with AWWA C213.

2.32 DISMANTLING JOINTS:

- A. Materials:
 - 1. Flanged Spool: AWWA Class D steel ring flange compatible with ANSI class 125 and 150 bolt circles. Provide pipe of ASTM A36 plate 1 percent cold expanded to size.
 - 2. End Ring and Body: ASTM A36 steel
 - 3. Gaskets: ASTM 2000 Virgin NBR suitable for wastewater service
 - 4. Bolts and Nuts: Type 316 stainless steel
 - 5. Tie Rods: Type 316 stainless steel
- B. Assembly Tolerance: 3 inches

C. Coating: Fusion bonded epoxy, NSF/ANSI 61 certified

D. Pressure Rating: 150 psi working pressure

E. Manufacturers

1. Romac

2. Viking Johnson

2.33 RESTRAINED FLANGE COUPLING ADAPTERS:

A. Materials:

1. Flanged Spool: AWWA Class D steel ring flange compatible with ANSI class 125 and 150 bolt circles, ASTM A36 steel or ASTM A283C steel.

2. End Ring and Body: ASTM A36 steel or ASTM A283C steel.

3. Gaskets: SBR suitable for wastewater service

4. Bolts and Nuts: HSLA carbon steel

5. Restrained gland and wedges: ASTM A536 grade 65-45-12.

B. Assembly Tolerance: 3 inches

C. Coating: Fusion bonded epoxy.

D. Pressure Rating: 150 psi working pressure

E. NSF 61 certified.

F. Manufacturers

1. Romac

2. Smith-Blair

3. Dresser

4. Baker

5. Viking Johnson

2.34 INSULATION:

A. General:

1. Provide insulation where specified and indicated.

2. Provide pre-molded or pre-formed pipe insulation.
 3. Provide insulation with a flame spread index of less than 25, and a smoke-developed index of less than 50 when tested in accordance with ASTM E84.
 4. Provide insulation with a maximum thermal conductivity of 0.7 Btu-in/h-ft²-degrees F at 75 degrees F mean temperature when tested in accordance with ASTM C177.
- B. Insulation for systems with an operating temperature of 60 degrees F or higher:
1. Type:
 - a. Pre-Molded Fiberglass.
 - b. Provide All Service Jacket (ASJ) consisting of white draft paper bonded to aluminum foil with fiberglass reinforcement in accordance with ASTM C1136 Type 1.
 - c. Provide self sealing lap.
 - d. Provide insulation thickness as indicated on the Process Pipe Schedule.
 2. Manufacturers:
 - a. Knauf Insulation.
 3. Accessories:
 - a. Butt Strips: Provide self adhesive butt strips for sealing circumferential joints between insulation sections. Provide strips manufactured from white kraft paper bonded to aluminum foil with fiberglass reinforcement in accordance with ASTM C1136 Type 1.
 - b. PVC Fitting Covers: Provide pre-molded, insulated, white glass finish, suitable for inside and outside use. Provide fitting covers manufactured from PVC material having a flame spread index of less than 25, and a smoke-developed index of less than 50 when tested in accordance with ASTM E84, PVC material shall meet the requirements of ASTM D1784.
 - c. Vinyl Tape: Provide white, adhesive backed vinyl tape, minimum 1-inch wide for sealing PVC fitting covers to insulation.
 - d. Tacks: Provide white coated, stainless steel, barbed tacks.
 - e. Aluminum Protective Jacketing: Provide 0.020 inch Stucco Embossed Aluminum Jacketing.

- f. Sound Barrier Jacketing: Provide a composite sound attenuating system comprised of an acoustic decoupler material laminated to 0.020 inch Stucco Embossed Aluminum Jacketing.
 - g. Stainless Steel Strapping: Provide Type 316 stainless steel strapping and wing seals. Provide strapping 1.2-inch wide or greater with a minimum thickness of 0.015-inch. Provide wing seals 1/2-inch wide or greater with a minimum thickness of 0.032 inches.
 - h. Sheet Metal Screws: Provide Type 316 stainless steel sheet metal screws.
- C. Insulation for systems with an operating temperature below 60 degrees F.
- 1. Type: Pre-molded, Flexible Closed Cell Elastomeric Foam.
 - 2. Provide self sealing lap for pipe sizes 6-inch and smaller. For pipe sizes above 6-inch and equipment provide Closed Cell Elastomeric Foam Sheets.
 - 3. Manufacturers:
 - a. Armacell Engineered Foams, AP Armaflex SS and AP Armaflex.
 - 4. Accessories:
 - a. Adhesive: Provide contact adhesive specifically designed for use with the insulation supplied.
 - b. Pipe support inserts: Provide a pre-fabricated insert designed to prevent damage to the insulation at the pipe support attachment point.
 - c. Provide an aluminum or stainless steel outer jacket, a foam inner core with plastic support and self sealing closure, or acceptable equivalent product.

2.35 STAINLESS STEEL HOSE AND FITTINGS:

- A. Manufacturers:
 - 1. Anamet, Inc Series 616
- B. Provide corrugated stainless steel hose
- C. Pressure Rating:
 - 1. Maximum working pressure: Unbraided type
 - a. 3/8-inch and smaller: 250 psi
 - b. 1/2-inch: 60 psi

- c. 3/4-inch to 1-inch: 40 psi
 - d. 1-1/4-inch: 20 psi
 - e. 1-1/2-inch: 15 psi
 - f. 2-inch to 3-inch: 10 psi
- 2. Maximum working pressure: Single braided type
 - a. 1/2-inch and smaller: 1000 psi
 - b. 3/4-inch to 2-inch: 450 psi
 - c. 2-1/2-inch to 4-inch: 300 psi
- 3. Safety Factor: 4:1
- D. Material:
 - 1. Core: Type 316
 - 2. Braid: Type 316L stainless steel
 - 3. Ends: Type 316L stainless steel
- E. Ends: Provide type as indicated
 - 1. 3/4 -inch to 3-inch: 150-lb (Class 150) welded female union end
 - 2. 3/4-inch and larger: 150-lb (Class 150) flat faced floating flanged

2.36 SAMPLING TAPS:

- A. Provide sampling locations as indicated on contract drawings. Coordinate location and arrangement with Engineer prior to installation. Additional sampling locations required by the Owner during construction shall be installed at Contractors expense.
- B. Sample taps shall be smooth nosed without interior or exterior threads and not be of the petcock type.

2.37 DIELECTRIC UNIONS

- A. Dielectric unions shall be Class 3000 O-ring type with thermos-baked polymer coating insulating type capable of insulating against galvanic corrosion and electrical current flow. Unions shall have material ends matching the joining pipe to which they are connecting, e.g., copper to copper or stainless steel to stainless steel. Zinc plated carbon steel connections shall not be used.

B. Dielectric coating shall be NSF 61 approved. O-ring shall be made from NSF 61 approved virgin EPM. Copper Alloy materials shall be certified lead-free.

C. Manufacturers:

1. Hart
2. Approved equal

2.38 SHOP PAINTING:

A. Provide in accordance with Section 09 96 00.

2.39 PIPE SUPPORTS:

- A. Provide in accordance with Section 40 23 19.01.
- B. Proceed with installation of pipe supports only after required building structural work has been completed and concrete has reached its 28 day compressive strength.
- C. Support piping to prevent forces applied on valves and equipment.

2.40 MECHANICAL SEALS

A. Manufacturers:

1. Garlock/Link-Seal
2. APS/Innerlynx

B. Materials:

1. Seal element: EPDM
2. Pressure Plate: Composite
3. Nuts and Bolts: Stainless Steel

2.41 FLANGE BOLTS AND NUTS

A. Flanges shall have stainless steel nuts and bolts as follows: Bolts shall have ASME B1.1, Class 2A threads, and be manufactured of ASTM A193, Grade B8M and conform to ASME B18.2.1, and nuts shall have Class 2A fit, square or hex heavy dimensions in accordance with ASME B18.2.2, and be manufactured of ASTM A194, Grade 8B heavy hex.

PART 3 - EXECUTION

3.01 HANDLING AND CUTTING:

- A. Mark pipe and fittings "Rejected" and remove from site when cracked or has received a severe blow.
- B. If permitted, cut on sound barrel at a point at least 12 inch from visible limit of crack, at Contractor's expense.
- C. Machine cut with milling type cutters, knives, or saws. Snap cutters, torch, or hammer and chisel are NOT ALLOWED. Examine for possible cracks.
- D. Chamfer cut ends if used for push-on joints.
- E. Do not cut glass lined pipes.

3.02 INSTALLATION OF PIPE:

- A. Install pipelines parallel to building walls wherever possible. Install piping to lines and grades indicated and support. Where temporary supports are used, provide temporary supports as specified in Section 40 23 19.01 to prevent shifting or distortion of pipe. Provide for expansion.
- B. Slope piping toward low points and provide for draining at low points.
- C. Before assembly, remove debris from inside of pipes and fittings.
- D. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces, clean gaskets and smooth burrs. Make up flanged joints tight, and prevent strain upon valves or other pieces of equipment. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped.
 - 1. Except as otherwise specified, provide number and size of bolts conforming to same ANSI standards.
 - 2. Provide Type 316 stainless steel hardware.
 - 3. Provide ring gaskets of materials designed for the service specified and indicated, 1/16-inch thick gaskets.
 - 4. Make up flanged joints tight with care being taken to prevent undue strain upon valves or other pieces of equipment.
 - 5. Bolt threads must fully engage the nuts. At a minimum the bolt must be flush with the nut and no more than 1/2-inch excess thread protruding from the nut.
 - 6. Provide insulating kits as specified herein.
- E. Install grooved joints in accordance with the manufacturer's written recommendations.

1. Grooved ends: Clean and free from indentations, projections, or roll marks.
 2. Gaskets: Molded and produced by the coupling manufacturer of an elastomer suitable for the service specified and indicated.
 3. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed.
- F. Install tierods, pipe clamps or bridles when sleeve type couplings or fittings are used in piping system as indicated, and at changes in direction or other places to prevent joints from pulling apart under pressures indicated in the Process Pipe Schedule.
- G. Examine pieces for damage. Do not install pieces that are damaged according to Engineer. If any damaged piece should be discovered after having been installed, remove and replace with a sound piece at no additional cost to the Authority.
- H. Handle pipe with equipment such as nylon slings and padded skids, designed to prevent damage to the coating. Repair abrasions and injuries to the coating prior to the application of insulation or prior to the application of final field coating.
- I. Support piping laid in trenches in trench on bed of selected backfill material which maintains desired line and grade.
- J. Use dielectric bushings or unions when ferrous pipes join nonferrous pipes carrying liquid either underground or elsewhere.
- K. Welding in accordance with ASME Section IX and AWS D1.1.
- L. Ductile Iron Pipe and Fittings:
1. Remove and replace defective pieces.
 2. Clear of all debris and dirt before installing and keep clean until accepted.
 3. Lay accurately to lines and grades indicated or required. Provide accurate alignment, both horizontally and vertically.
 4. Provide firm bearing along entire length of buried pipelines.
- M. Appurtenances: Set valves, fittings and appurtenances as indicated.

3.03 INSTALLATION OF LINING AND COATING:

- A. After installation of pipe, fittings, and specials, clean, prime, line, and coat as specified for pipe adjacent to weld unlined or uncoated ends adjacent to field welded joints, including weld proper. Repair any damage to lining in accordance with lining manufacturers written recommendations.

- B. Preparation of surfaces to be lined and coated after installation of pipe for shop application of coal tar epoxy, except remove foreign matter, including all damaged lining or coating materials, by scraping, chipping, or brushing, and surfaces cleaned to bright metal free of all rust, slag, and scale by means of wire brushing or sand blasting.
- C. Use open ends or access manholes for entry for application of interior linings to unlined ends.
- D. Pour holes are not allowed.
- E. After installation of pipe, fittings, and specials, shop coat on exterior shall be touched up followed by a field coat prior to encasing in concrete.

3.04 INSTALLATION OF FLANGED COUPLING ADAPTERS:

- A. Install flange coupling adapters in strict accordance with coupling manufacturer's recommendations.

3.05 WALL SLEEVE SEALS:

- A. Expand rubber against pipe and sleeve by tightening bolts when assembled around pipe and inserted in wall.

3.06 TEMPORARY PLUGS:

- A. Close open ends of pipe with temporary plugs or caps when pipe installation is not in progress. Use watertight plugs for exterior, buried piping and if water or debris is in trench when work is resumed, do not remove until adequate provision has been made to prevent any water or debris entering pipe even if it necessitates dewatering trench.

3.07 JOINTS AND COUPLINGS:

A. Push-on Joints:

1. Insert gasket into groove bell. Apply thin film of nontoxic gasket lubricant over inner surface of gasket in contact with spigot end.
2. Insert chamfered end into gasket. Force pipe past it until it seats against socket bottom.

B. Bolted Joints:

1. Remove rust-preventive coatings from machined surfaces.
2. Clean pipe ends, sockets, sleeves, housings, and gaskets and smooth all burrs and other defects.
3. Use torque wrench to tighten to correct range of torque not to exceed values specified below:

TORQUE RANGE VALUES		
Nominal pipe size, in	Bolt diameter, in	Range of torque, ft-lb
3	5/8	40-60
4-24, incl.	3/4	75-90
30, 36	1	100-120
42, 48	1-1/4	120-150

C. Flanged Joint:

1. Make up tight.
2. Do not put strain on nozzles, valves, and other equipment.
3. Bolt threads must fully engage the nuts. At a minimum the bolt must be flush with the nut and no more than 1/2-inch excess thread protruding from the nut.

D. Mechanical Joints:

1. Wire brush surfaces in contact with gasket and clean gasket.
2. Lubricate gasket, bell, and spigot with soapy water.
3. Slip gland and gasket over spigot, and insert spigot into bell until seated.
4. Seat gasket and press gland firmly against gasket.
5. After bolts inserted and nuts made finger-tight, tighten diametrically opposite nuts progressively and uniformly around joint by torque wrench. Torque bolts to values specified above.

E. Flexible Joints:

1. Clean and dry before assembly.
2. Place gaskets, rings, glands and followers in position in back of spigot ball.
3. Coat ball and socket with thin film of lubricant conforming to joint manufacturer's standards.
4. Insert ball and seat in socket. Seat gasket against ball.
5. Boltless joints:
 - a. Assemble retainer rings and glands conforming to manufacturer's standard.
 - b. Lock in place with lead strips.

F. Grooved Couplings:

1. Clean grooves and other parts.
2. Coat ends of pipe and outside of gasket with soft soap or silicone and slip gasket over one pipe end.
3. Bring pipes to correct position and center gasket over pipe ends with lips against pipe.
4. Place housing sections, insert bolts and tighten nuts until housing sections in metal-to-metal contact.
5. After assembly and inspection and before backfilling, coat exterior surfaces of buried couplings, including bolts and nuts, with heavy-bodied bituminous mastic.

G. Tapped Connection:

1. Drill and tap normal to longitudinal axis.
2. Drilled by skilled mechanics using proper tools.
3. Use only tapered threads.

H. Electrical Conductors:

1. Install pipes so terminal strips are aligned.
2. Install jumper strips and tighten bolts.

3.08 VIO-B POLYETHYLENE ENCASEMENT

- A. Provide Vio-B polyethylene encasement for use with ductile iron pipe in accordance with ANSI/AWWA C105/ A21.5, Polyethylene Encasement for Ductile Iron Pipe Systems.
- B. Provide the Vio-B polyethylene encasement for use with ductile iron pipe systems consisting of three layers of co-extruded linear low density polyethylene (LLDPE), fused into a single thickness of not less than eight mils.
- C. Provide the inside surface of the polyethylene wrap in contact with the pipe exterior infused with a blend of antimicrobial compound to mitigate microbiologically influenced corrosion and a volatile corrosion inhibitor to control galvanic corrosion.
- D. Install ductile iron pipe and the polyethylene encasement in accordance with AWWA C600 and ANSI/AWWA C105/A21.5 and also in accordance with all recommendations and practices of the AWWA M41, Manual of Water Supply Practices – Ductile Iron Pipe and Fittings.
- E. Overlap the wrap one foot in each direction at joints and secure in place around the pipe. Provide any wrap at tap locations taped tightly prior to tapping and inspected for any repairs following the tap and repair as required.

3.09 PHYSICAL CHECKOUT, FIELD AND FUNCTIONAL TESTING:

- A. Clean dirt, dust, oil, grease and other foreign material, before pressure and leakage tests.
- B. Water for testing provided by the Contractor.
- C. Pressure and Leakage Tests:
 - 1. Provide temporary testing plugs or caps; pressure pumps, pipe connections, meters, gages, meters, gages, equipment, and labor.
 - 2. Test pipelines in sections of acceptable length.
 - 3. Test when desired and comply with specifications.
 - 4. Test pipelines in excavation or embedded in concrete before backfill or placing of concrete and test exposed piping before field painting.
 - 5. Fill section of pipe with water and expel air. If hydrants or blowoffs are not available at high points for releasing air, make necessary taps and plug after test completion.
 - 6. Maintain section full of water for 24 hours before conducting combined pressure and leakage test.
 - 7. Pressure and leakage test consists of first raising pressure (based on elevation of lowest point of section under test and corrected to gage location) to pressure in psi numerically equal to test pressures indicated in the Process Pipe Schedule.
 - 8. No visible leakage in joint is acceptable.
 - 9. If unable to achieve and maintain specified pressure for one hour with no additional pumping, section has failed to pass test.
 - 10. If section fails pressure and leakage test, locate, uncover, and repair or replace defective pipe, fitting, or joint, and conduct additional tests and repairs until section passes test at no additional cost and without any time extensions.
- D. Make piping connections to equipment with pipe in a free supported state and without application of vertical or horizontal forces to align piping with the equipment flanges.
- E. Do not cover joints in underground piping with backfill material until piping has successfully passed pressure test.
- F. Test pressures as indicated in Process Pipe Schedule.
- G. Repair faulty joints even to extent of disassembling and remaking joint, remove defective pipe and fittings and replace in manner satisfactory to the Owner.

3.10 DISINFECTING AND FLUSHING:

- A. Disinfect potable water lines using procedures and materials conforming to AWWA C651.
- B. Dosage to produce minimum 10 ppm after minimum of 24 hour contact period.
- C. After treatment, flush with clean water until residual chlorine content less than 0.2 ppm.
- D. Prevent contamination of water in existing water mains. Neutralize chlorine content of water used in disinfecting and flushing accordance with AWWA C651.

3.11 FIELD PAINTING:

- A. Provide in accordance with Section 09 96 00.

3.12 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 61 13

PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide process control system general provisions as indicated and in compliance with Contract Documents.

1.02 REQUIREMENTS OF WORK

- A. Supply, install, commission and provide warranty for a complete and fully documented instrumentation and control (I&C) system as shown on the drawings and specified herein. The I&C system will form a subsystem of the overall plant control system and contains vendor component subsystems specified in this and other sections of the specification.
- B. Programming and configuring all non-vendor-provided PLCs, network enclosures and equipment, and operator interface units.
- C. Component subsystems of the I&C system will include, but are not limited to, the following:
 - 1. Primary elements and transmitters.
 - 2. Final control elements.
 - 3. I&C field devices.
 - 4. I&C junction boxes, local control panels, and marshalling panels.
 - 5. Instrumentation cabling.
 - 6. Communication Network Cabling.
 - 7. Instrumentation power supplies.
 - 8. Conduit and cable tray.
 - 9. Programmable logic controller (PLC) based control system.
 - 10. Human Machine Interfaces (HMI).
- D. The Contractor's responsibility also includes receiving, un-crating, examining for shortages or damage, assembling, field fitting, installing, mounting, wiring and testing of vendor supplied component subsystems including all loose supplied components of the vendor package.

- E. Where packaged, stand-alone control systems are supplied under other divisions of this specification, provide installation and cabling to connect to the required remote monitoring and/or controllers and all loose supplied components of the vendor package. Provide end-to-end commissioning and ensure the correct functionality of any equipment supplied under other divisions of this specification.
1. Control panel shop drawings shall be drawn to scale using manufacturer's CAD drawings for panel components and instruments.
 2. Provide catalog cut sheets with proposed items and options clearly identified.
 3. Scale the drawings to show proper location and dimensions of all panel mounted devices, doors, louvers, and subpanels.
 4. Provide panel legends and an accurate Bill of Materials.
 5. Provide ladder diagrams with rung numbers, wire numbers, and terminal numbers.
 6. Show point-to-point and terminal-to-terminal wiring within panels.
- F. Documentation provided by the Contractor shall include as a minimum:
1. Equipment descriptive data.
 2. Equipment installation instructions, service manuals, operation and maintenance (O&M) manuals, bills of materials, and recommended spare parts lists.
 3. Schematics and interconnection wiring diagrams sealed by a Professional Engineer registered in the State of Texas.
 4. Records of conductor identification, field terminals, cable lists, changes, etc.
 5. I&C panel Shop Drawings, face layouts, schematics, and point-to-point wiring diagrams sealed by a Professional Engineer registered in the State of Texas.
 6. Records of as-built information for the complete instrumentation system.
 7. For the programmable logic controller (PLC) based control system, the Contractor shall provide detailed documentation of the system hardware and software. Minimum software documentation shall include a detailed operating description, flow charts that describe the functionality of the PLC program, a memory map, and the PLC program documentation. This information shall be submitted at the Shop Drawing stage.
 8. For the HMI based control system, the Contractor shall provide detailed documentation of the system hardware and software.

G. Documentation provided by the Contractor shall be formatted as follows:

1. Process and Instrumentation Diagrams (P&IDs) – Depict the general design intent of the process and control systems.
2. Instrument List – A tabular index of the detailed information for control system devices shown on the P&IDs. The list shows the appropriate support documentation for the specified devices' supply and installation.
3. Input/Output List – A tabular index of the control system I/O points shown on the P&IDs, providing a description of the application and function together with references to supporting documentation.
4. Instrument Specification Sheets – Detail the relevant technical data for the supply of devices.
5. Instrument Loop Diagrams (ILDs) – Show typical interconnections and hook-up of devices and control circuits. The Contractor is to produce an ILD for each device and record all relevant information on each sheet for submission at the completion of the work. Fill in all terminal and wiring numbers etc. from the reviewed shop drawings as they become available. A set of 'B' size (11" x 17") ACAD drawings and associated files will be made available to the successful bidder. Where an ILD is not shown for wiring of simple devices provide a legible sketch for as-built information.
6. Location Drawings – Indicate in plan and/or elevation views where the instrument elements are physically located. These drawings are provided to assist the Contractor in estimating the amount of wire, cable, cable tray and ducting required.
7. Standard Details – Provide a reference for installation, operation, and other instructions pertinent to a particular device. Where standard details are not provided, The contractor shall follow manufacturers recommended installation details.
8. Detailed Specification - Lists qualifications, quality of materials and workmanship, and supplementary information.

H. Related Work:

1. Process: Division 40
2. Mechanical: Division 23
3. Electrical: Division 26

I. Codes, Rules, Permits and Fees:

1. Comply with all laws, ordinances, rules, regulations, codes, and orders of all authorities having jurisdiction relating to this work.

2. Comply with all rules of the electrical Safety Act of the State, National Fire Protection Association (NFPA), Underwriters Laboratories (UL) and the applicable building codes, whether specifically shown on drawings or not.
3. Give all required notices, submit drawings, obtain all permits, licenses, and certificates, and pay all fees required for this work.
4. Furnish a certificate of final inspection and approvals from inspection authorities to the Engineer.

J. Qualifications:

1. The instrumentation subcontractor shall be a firm normally engaged and fully competent in the type of work described in this section of the specification. The firm shall have been continuously and successfully engaged in this business for at least five (5) years.
2. Submit with the bid a list of similar projects recently completed and resumes of the personnel proposed for the project.
3. The instrumentation subcontractor shall be experienced in the process and instrument requirements of this contract.
4. The instrumentation subcontractor shall show that it maintains a fully equipped and qualified organization, capable of performing the present work and of providing warranty service to the system after installation.
5. Qualified journeyman instrument mechanics that are familiar with the devices being installed shall perform all instrument hook-ups, calibrations and checkouts.
6. Qualified journeyman electricians shall perform all control wiring installation and connections.

K. Standards of Workmanship:

1. Execute all work in a manner which will result in the completed installation presenting an acceptable appearance, to a level of quality defined in the general conditions of this specification.
2. Employ a competent supervisor and all necessary licensed tradesmen to complete the work in the required time.
3. Arrange and install products to fit properly into designated building spaces.
4. Install products in accordance with the recommendations and ratings of the product manufacturers.

5. Supply and execute installation of all instrumentation control tubing in accordance with Division 40.

L. Contract Drawings and Specifications:

1. Refer to Division 1.
2. Supply and install all items and accessories specified by the drawings or the specification in the quality and quantity required. Perform all operations as designated by the specifications according to the methods prescribed, complete with all necessary labor and incidentals.
3. Treat any item or subject omitted from this division's Specifications or drawings, but which is mentioned or reasonably specified in other divisions' specifications or drawings and pertains to the I&C system, as being integral to the overall system. Provide such specified items or subjects.
4. Provide all minor items and work not shown or specified but which are reasonably necessary to complete the work.
5. If discrepancies or omissions in the drawings or specifications are found, or if intent or meaning is not clear, consult the Engineer for clarification before submitting the bid response.
6. The responsibility to determine which division provides various products and work rests with the Contractor. Additional compensation will not be considered because of differences in interpretation of specifications.

1.03 REFERENCES

A. International Society of Automation (ISA):

1. S5.1: P&IDs and Tagging.
2. S5.4: Instrument Loop Diagrams.
3. S7: Instrument Air.
4. S12: Electrical Equipment for Hazardous Locations.
5. S18.2: Alarm Management.
6. S20: Instrument Specifications.
7. S50: Electrical Control Signals.
8. S75: Control Valve Design, Specification and testing.
9. S96: Valve Actuators .

10. S99: Control System Cyber Security.

11. S101: Human-Machine Interfaces.

1.04 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00:

1. Sustainable Design Submittals.

B. Tender submittals:

1. Submit an equipment list indicating the type and make of all equipment and materials proposed for this project within 10 business days of award of contract.

C. Receiving, storing, and protection of components during construction:

1. Examine each component upon delivery to site. Report all damage noted to the Engineer prior to accepting or rejecting delivery. All instrumentation primary elements, control components, panels, etc. shall be placed in a secure, dry, heated storage building. Maintain the space temperature above 50 degrees Fahrenheit and the space relative humidity below 50%.

2. Perform a preliminary examination upon delivery to ensure that:

a. All I&C components supplied for this project under this section of the specifications comply with the requirements stated in the instrument specification sheets.

b. All I&C components supplied under other sections of these specifications, to be connected to I&C components supplied under this section of the specifications, comply with the requirements stated in the contract documents.

c. Itemize all non-conformities noted above and forward them to the Engineer. Any delays in construction resulting from the delivery to site of non-conforming I&C components shall be borne by the Contractor.

d. Do not install primary elements or other sensitive equipment until construction is sufficiently completed to provide an "operating condition" environment. Notify the Engineer prior to installing any equipment of this type.

e. Ensure that covers where required are properly installed on all equipment. Provide all covers, padding, guards, etc. as required to guard any equipment against damage.

f. Follow the manufacturer's recommendation for the storage of all I&C components.

3. Take all necessary precautions to ensure that equipment is supplied free of damage. If deemed necessary by the Engineer, damaged equipment shall be replaced with new Product. The Contractor shall bear any costs due to construction delays resulting from the delay in delivery of acceptable equipment.
- D. Submit a schedule within 30 days of award of contract to the Engineer showing projected ordering and delivery dates of all products to meet the required construction schedule. Provide all necessary information regarding ordering and delivery dates for those product whose delivery effects the construction schedule.
- E. Submit shop drawings for all products supplied by this Division. Submit shop drawings for review prior to purchase of any products or equipment and sufficiently in advance to allow ample time for checking.
1. Provide PDF versions with electronic bookmarks.
 2. Provide with a copy of the specification section with exceptions noted including explanation.
 3. Control, PLC, and Network cabinet shop drawings
 - a. Provide interior and exterior dimensioned layouts of all panels.
 - b. All interior components shall be shown using actual equipment manufacturer CAD drawings and blocks. Generic rectangles for terminals, PLCs, or other equipment shall are not acceptable in Shop Drawings.
 - c. Shop drawings shall show all wire tags and terminal block tags.
- F. Contractor to review, modify, and approve the shop drawings prior to submitting shop drawings to the Engineer for review. Contractor approval of a drawing indicates the following:
1. The drawing has been checked by the person making the approval.
 2. The equipment or material complies in all respects with the requirements of the specifications and drawings.
 3. The quantities indicated are correct.
 4. The physical dimensions of the components are such that they can be installed without interference with the building structure or other equipment, and after installation, there are sufficient clearances on all sides for maintenance, servicing and operation of the equipment.
 5. The points of attachment are clearly indicated, i.e. TOP, BOTTOM, SIDE, etc.
 6. The arrangement and location are properly oriented.

7. The product is suitable for its intended use.
 8. The submission consists of sufficient information to adequately convey the scope of supply and the specific product to be supplied is highlighted.
 9. The submission contains sufficient information to install the equipment or systems.
- G. Stamp and sign the shop drawing to show approval, indicating the above has been complied with. If Contractor revisions are too extensive, return the submission to the manufacturer for revision, then repeat the shop drawing approval process before submitting to the Engineer.
- H. Manufacture of products shall conform to shop drawings marked as reviewed by the Engineer and returned to the Contractor.
- I. Keep one complete, maintained set of shop drawings at the job site during the construction period. Record site modifications.
- J. Refer to Division 01 for further information on Shop Drawing submittals.
- K. Operation & Maintenance Manuals
1. Refer to Section 01 78 23 for O&M manual submittal information.
 2. In addition to the requirements specified in Division 1, provide the following information:
 - a. Table of Contents – Arrange contents sequentially by systems under section numbers. Label tabs of dividers between each to match section numbers in the Table of Contents.
 - b. Systems Descriptions – A brief synopsis of each system typed and inserted at the beginning of each section. Include sketches and diagrams where appropriate.
 - c. O&M instructions of all equipment and controls – These operating instructions need not be manufacturer's data but may be typewritten instructions in simple language to guide the District in the proper O&M of this installation.
 - d. A copy of all wiring diagrams complete with wiring coding.
 - e. Include type and accuracy of instruments used.
 - f. Set of final reviewed Shop Drawings.
 - g. Provide a tabulated list of all consumables utilized (fuses, lamps, etc.) indicating where used, type, rating and reorder details.

L. Record Drawings:

1. Maintain on-site a complete set of as-built drawings as listed in Division 1 of this specification.
2. In addition to the requirements as stated in Division 1, record on the drawings the following information:
 - a. all changes alterations or additions
 - b. all instrumentation cable and control tubing
 - c. all changes to the numbers and location of outlets, motors, panels and end devices that may occur during the course of the work.
3. Before requesting the final completion certificate make any necessary final corrections to the drawings, sign each print as a certification of accuracy and deliver all sets to the Engineer for approval.

1.05 SPARE PARTS:

- A. Comply with requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. The I&C Subcontractor shall be:
 1. APCO Inc., North Salt Lake, UT, 801-519-9500
 - a. The point of contact is Cory Topham, Senior Control Engineer, 801-718-6672
 2. No other I&C Subcontractor will be considered.

1.07 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.08 PROJECT/SITE CONDITIONS:

- A. Classification of Plant Areas:
 1. Refer to Division 26

PART 2 - PRODUCTS

2.01 GENERAL

- A. Refer to the requirements of Division 01.
- B. Selected Products:
 - 1. Provide products and materials that are new and free from all defects.
 - 2. Products and materials called for on the drawings or in the specifications by trade names, manufacturer's name and catalogue reference are to be used as the basis for the bid submission.
 - 3. The design has been based on the use of the first named product where multiple products have been listed.
- C. Quality of Products:
 - 1. All Products provided to be NEC and UL approved where applicable.
 - 2. If Products specified are not NEC and UL approved, obtain approval of the relevant State regulatory authority. Pay all applicable charges levied and make all modifications required for approval.
 - 3. Refer to Division 1 of this specification for further information.
- D. Uniformity of Manufacture:
 - 1. Unless otherwise specifically called for in the specification, uniformity of manufacture to be maintained for similar products throughout the work.
- E. Product Finishes:
 - 1. Contractor to specify proposed finishes to be used for Engineer's review.
- F. Use of Products During Construction:
 - 1. Any equipment used for temporary or construction purposes is to be approved by the Engineer and in accordance with Division 1 of this specification. Clean and restore to "as new" condition all equipment prior to the time of substantial completion.

2.02 INSTRUMENTATION:

- A. General:
 - 1. Instruments are to be suitable for the environmental conditions in which they are to be installed.

2. Determine where injurious conditions may be expected to occur and make proper provision to protect the instruments to ensure their proper and reliable operation.
3. Provide power surge protection, heating cables, and devices to protect instruments, equipment, and lines from being functionally impaired or damaged by power surges or environmental conditions such as moisture or freezing.

B. Identification:

1. Refer to Division 26 for general identification requirements. Provide lamacoid nameplates with 0.25 inch black lettering on white background. Identify the loop tag number (where applicable) and the device name, function, and instrument range or setpoint value on the nameplate.
2. For field instrument components, provide the component with a stainless steel metal tag firmly wired to the device and identified with the equipment code, process code, process function/loop number, unit number, and differentiation letter (if applicable).
 - a. All field instrument component tags and control panel tags shall contain the division and facility WW8000 as a prefix to the rest of the tag. Refer to the Instrument List and Network Architecture Diagram for additional details.
3. Identify all wires where they terminate at the marshalling panels, junction boxes, control panels, and field devices with a heat shrink sleeve with machine printed labelling.
4. Clearly mark all panels, pull boxes, junction boxes, etc. to indicate the nature of service.
5. Provide neatly typed circuit directories for panel power distribution systems to indicate loops or devices powered by the circuit and the fuse size.
6. Identify all exposed control conduits at all pull box locations, where the conduits enter or leave a room, and 40 feet on center throughout the room. This shall apply to conduits above removable ceilings. Refer to Division 26 for conduit identification.
7. For direct current wiring use black for positive and white for negative.
8. For thermistor wiring to motors use red and blue colored insulated wire.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Refer to the requirements of Division 01.

- B. No additional compensation will be given for extra work due to existing conditions which a site examination prior to tender should have disclosed.

3.02 COORDINATION WITH OTHER DIVISIONS:

- A. Examine the drawings and specifications of all divisions and become fully familiar with the work. Before commencing work, obtain a ruling from the Engineer on any conflicting issues between divisions. No compensation will be made for any costs arising from conflict not identified before work has commenced.
- B. Coordinate the work to be performed under this section of the specification with all divisions installing equipment to ensure that there are no conflicts.
- C. Install anchors, bolts, pipe sleeves, hanger inserts, etc. required in ample time to prevent delays to other divisions' installation work.
- D. Lay out the work and equipment with due regard to architectural, structural, and mechanical features. Architectural and structural drawings take precedence over electrical drawings regarding locations of walls, doors, and equipment.
- E. Structural members shall not be cut without prior approval of the Engineer.
- F. Examine previously constructed work and notify the Engineer of any conditions which prejudice the proper completion of this work.

3.03 PRODUCT HANDLING:

- A. Use all means necessary to protect the products included in this division before, during and after installation, and to protect products and installed work of all other trades.
- B. Any damage to the products and/or installed work shall be repaired or replaced to the approval of the Engineer by the Contractor at no additional cost to the District.
- C. Remove advertising labels from all products installed that have such labels attached. Identification, NEC, and UL labels are not to be removed.
- D. Remove dirt, rubbish, grease, etc. resulting from work performed under this section of the contract from all surfaces.

3.04 SEPARATION OF SERVICES:

- A. Maintain separation between the electrical wiring system, piping, ductwork and the instrumentation cables so that each system is isolated (except at approved connections to such systems) to prevent galvanic corrosion. In particular, contact between dissimilar metals, such as copper and aluminum, in damp or wet locations is unacceptable.

B. Do not support wiring from pipes, ductwork, etc. Hangers for suspended ceilings may be used for the support of wiring only when approval is obtained from the Engineer and the ceiling installer, and only if approved clips or hangers are used.

C. Classifications of Circuits:

1. The circuit categorization shall of first priority follow National Electric Code (NEC, NFPA 70) with respect to separation for electrical safety and the following shall apply with respect to electro-magnetic compatibility:

Very Noisy	High voltage circuits and their associated grounding
	High current (>200A) LV circuits.
	Harmonic-rich LV circuits.
	DC circuits: un-suppressed or above 50V.
Noisy	Low current class two (2) circuits.
	Medium power pulsed or radio frequency circuits.
Indifferent	ELV digital status circuits.
	Intrinsically safe circuits.
	Telecommunications circuits.
	Fire alarm and emergency lighting circuits (note that some fire alarm circuits may fall into the category of signal circuits).
	Any other emergency, shutdown, or high integrity circuit (e.g. toxic gas alarm).
Sensitive	Analogue signal circuits.
	Data communication circuits.
Very Sensitive	Low level voltage and current signals (e.g. from instrument sensors).

D. Separation of Circuits:

1. This section relates to the running of cables carrying differing types of circuit in close proximity to one another and to other services. Sensitive circuits shall normally be run in overall shielded cable. Very sensitive circuits shall normally be run in individually twisted pair shielded cable.
2. For cables sharing the same support/containment system, the following shall provide guidance to minimize extraneous interference.

Segregation between Circuits	Very Noisy	Noisy	Indifferent	Sensitive	Very Sensitive
Very Noisy	Thermal grouping as per NEC.	6 inches	12 inches	12 inches	12 inches
Noisy	6 inches	Thermal grouping as per NEC Code.	6 inches	6 inches	6 inches

Segregation between Circuits	Very Noisy	Noisy	Indifferent	Sensitive	Very Sensitive
Indifferent	12 inches	6 inches	Separation of circuit types.	4 inches	4 inches
Sensitive	12 inches	6 inches	4 inches	Touching	2 inches
Very Sensitive	12 inches	6 inches	4 inches	2 inches	Touching

3.05 WIRE AND CABLE:

- A. Refer to Section 26 05 20 “Electric Wires and Cables”.

3.06 EQUIPMENT CONNECTIONS:

- A. Prior to the connection of signal wiring to process control and instrumentation devices, check the device voltage rating and polarity for compatibility with the corresponding loop and/or schematic diagram. Where device and circuit characteristics are found to be incompatible, the connections are not to be made. Report the condition immediately to the Engineer.
- B. All control wiring diagrams illustrate typical control circuits applicable to the type of equipment specified. Control circuits may vary with different manufacturers’ equipment. Verify all control circuits with the manufacturers of the equipment and make any corrections to the control wiring diagrams that may be required.
- C. Provide power disconnect terminals in marshalling panels for all devices and PLC inputs/outputs sourced from the panel. Provide local power disconnect switches for all 120VAC power instruments. Mount adjacent the instrument.
- D. Provide a disconnecting means in the cable connecting each ultrasonic transponder to the transmitter. This disconnect shall consist of a terminal strip in a local water proof junction box.

3.07 WIRING TO EQUIPMENT SUPPLIED BY OTHERS:

- A. Equipment supplied by others, that have loose supplied external or field mount control devices, are to be installed, wired and commissioned by this division.

3.08 ACCESS PANELS

- A. Provide access panels where I&C system junction boxes are concealed. Panels to be of adequate size for servicing of the concealed junction box and complete with necessary frames and hinged doors held closed with captive fasteners.

- B. In removable ceiling areas provide markers on ceiling tile to locate equipment requiring access. Use a 1 inch diameter blue circle painted on the access panel to indicate that it is for instrumentation and control system access.

3.09 INSTRUMENT MOUNTING STANDS:

- A. Supply and install instrumentation mounting stands as required. Stands are to be either floor or wall mounted. The mounting stands are to be fabricated from aluminum or galvanized steel. Stands shall be galvanized after fabrication.
- B. Supply and install protective drip shields for any exterior stand-mounted instrumentation equipment. The drip shield is to extend 2 inches at the top and sides from the front face of the equipment. The drip shield is to be fabricated from aluminum.

3.10 SEALING OF WALL AND FLOOR OPENINGS:

- A. Seal all conduit and cable entries passing through outside walls of buildings, through partition walls separating electrical rooms from other areas, through fire separations, and through floors above grade.
- B. Seal openings after all wiring entries have been completed.
- C. Sealing material shall be fire resistant and not contain any compounds which will chemically affect the wiring jacket or insulating material. Cable penetrations through fire separations, if required, are to be sealed in accordance with Division 26 Electrical.
- D. Provide sleeves of galvanized steel pipe with machine cut ends of ample size to accommodate conduits passing through walls, partitions, ceilings, floors, etc.
- E. For wall partitions and ceilings the ends shall be flush with the finish on both sides. For floors, the ends shall extend 4 inches above finished floor level.
- F. Fill the space between the sleeve and the conduit with fire stop material and caulk around the top and bottom with approved permanently resilient, non-flammable and weatherproof silicone base compound. Ensure that the seal is compatible with the floor and ceiling finishes.
- G. Locate the sleeves and position exactly prior to construction of the walls and floors.
- H. Failure to comply with the above requirements shall be remedied at the Contractor's expense.

3.11 CONNECTIONS TO MECHANICAL, ELECTRICAL AND EXISTING SYSTEMS:

- A. Refer to Division 26 for the required tie-in procedures.

3.12 TAGGING STANDARDS FOR DEVICES AND WIRING:

- A. Tag all devices, wires, and I/O using the assigned loop, equipment, or device tag name. Where tag naming and numbering is not defined the Engineer will provide naming and numbering.

3.13 TESTING OF INSTRUMENTATION LOOPS:

- A. After all devices within a loop have been connected, check the loop for correct functioning and interaction with other loops, where applicable. Provide written notice to the Owner and Engineer when the loops are going to be tested so that the tests may be witnessed at the Engineer's discretion.
- B. Check the operation of final control elements such as solenoid valves, actuators, etc. by manual control before checking with automatic control.
- C. Check and simulate all alarms and shutdown functions.
- D. Verify the status of all points connected or accessible to the plant control and monitoring system.
- E. Where applicable, test all tubing for leaks in compliance with ISA RP7.1. Isolate all instruments when tubing is being tested to protect against over pressure.
- F. Perform tests and record results on the test data forms that are included in this section. Develop additional and/or more detailed test forms as necessary to suit more complex instrumentation.
- G. Sign and date all test reports. Submit the test reports to the Engineer within five (5) working days of testing.

3.14 CALIBRATION:

- A. Instruments are to be factory pre-calibrated. Verify calibration “in situ” after installation. Provide a printed record of the factory calibration and as constructed parameters for “smart” devices. Include device tag numbers and serial numbers in the calibration records.
- B. Instruments are to be set up and calibrated by an accredited instrument technician working under the approval of the instrument manufacturer.
- C. Calibrate all instruments to the accuracy specified in in Section 40 70 00, or to the manufacturer’s stated accuracy of the instrument when required accuracy is not specified.
- D. Prior to instrument installation perform the following applicable calibration for each instrument and its associated signal conditioning equipment:
 - 1. Calibrate all inline flow meters by a draw-down test.
 - 2. Calibrate all density meters by lab samples.

3. Calibrate all vacuum and pressure instruments by manometer or certified calibration standard.
4. Calibrate gas detectors using standard gas samples.
5. Calibrate temperature instruments against a standard lab thermometer or certified calibration standard.

3.15 INSTALLATION AND PERFORMANCE TESTING:

- A. Refer to the requirements of Section 01 78 25 for additional requirements.
- B. Inspections
 1. Provide two (2) weeks written notice to the Owner and Engineer prior to energizing any system to allow for inspection by the Owner and Engineer of the following:
 - a. Proper mounting.
 - b. Proper connections.
- C. During commissioning, demonstrate to the Engineer proper calibration and correct operation of instruments and gauges.
- D. Commissioning of the I&C system is to include but not be limited to the following:
 1. Verify installation of components, wiring connections, and piping connections.
 2. Supervise wiring continuity and pipe leak tests.
 3. Verify instrument calibration “in situ” and provide written reports.
 4. Function check and adjust the I&C equipment under operational conditions.
 5. Coordinate I&C equipment supplier’s service personnel as required for complete system testing.
 6. Instruct plant personnel in correct method of I&C equipment operation.
 7. Direct plant personnel at hand-over as to final adjustment of the system for correct operation of plant.
 8. Ensure that the I&C equipment suppliers cooperate to complete the Work of this section.
 9. Verify signal levels and wiring connections to all I&C equipment.

10. Coordinate and cooperate with District staff and the Engineer to commission the interface between the existing Plant supervisory control and data acquisition (SCADA) system and the new PLC based control systems.

3.16 TRAINING:

- A. Provide training, described in detail in Section 01 78 25, as required by the plant's personnel to become fully competent in the proper operation and maintenance of all control devices, control valves, and ancillary instrumentation described under this section of the specifications.
- B. For the PLC based control systems, the Contractor shall provide maintenance training that includes a review of the PLC program, system troubleshooting, and identification of programmed system variables such as set-points, alarms, and statuses.
- C. Training shall be provided for the City's Operations and Maintenance personnel in customized classes for Operations staff and customized classes for Maintenance staff. Before any classes are schedule, provide outlines and training plans for approval, for proposed personnel
 1. Operations
 - a. All activities required for proper day-to-day operations of the Process Control System equipment provided under division 40.
 - b. Provide one four hour Operations class at the site and coordinate attendees with the Owner.
 2. Maintenance
 - a. All maintenance activities required for continued proper operation of the Process Control System equipment including daily, weekly, monthly, and yearly maintenance activities for all Process Control System equipment.
 - b. Provide one four hour Operations class at the site and coordinate attendees with the Owner.

3.17 CLOSEOUT ACTIVITIES:

- A. Provide in accordance with Section 01 77 00.

3.18 SCHEDULES:

- A. Instrument Test Report (ITR).
- B. Loop Check Report (LCR).

INSTRUMENT TEST REPORT

SYSTEM: _____
SERVICE: _____ TAG NO.: _____
LOCATION: _____
MAKE: _____ MODEL: _____
SERIAL NO.: _____ CSA: _____
ELEMENT: _____ RANGE: _____
DESIGN SETTING/RANGE: _____ CONTACT TO: _____ ON: _____
SIGNAL IN: _____ OUT: _____ ASSOCIATED INSTRUMENT: _____
INSTRUMENT CONDITION: _____ CONFORM TO SPEC: _____
PROJECT NO: _____ DATA SHEET: _____

	TEST 1				TEST 2			
TEST METHOD								
	INPUT		OUTPUT		INPUT		OUTPUT	
PROCESS	INC.	DEC.	INC.	DEC.	INC.	DEC.	INC.	DEC.
TEST POINT 1								
TEST POINT 2								
TEST POINT 3								
TEST POINT 4								
TEST POINT 5								
COMMENTS								
GRAPHS								

TESTED BY: _____

CHECKED BY:

DATE: _____

DATE:

LOOP CHECK REPORT

- ☐ CHECKED OUT OK
- ☐ NOT APPLICABLE
- ☐ FURTHER ACTION REQUIRED

	INSTRUMENT TAG NO.									
LOOP NO. _____										
SHEET NO. _____										
P & I DWG. NO. _____										
INSTALLATION COMPLETE										
Primary Element.										
Impulse Lines.										
Block and Drain Valves.										
Air Supply/Filter/Reg.										
Wiring.										
Tracing/Insulation/Housing.										
Mounting and Location.										
PLC/SCADA I/O & Status.										
CALIBRATED										
Impulse Lines Press. Tested.										
LOOP CHECKED										
Element to Receiver.										
X Mtr. To Receiver.										
X Mtr./Trans. to Receiver.										
X Mtr./Trans. to Switches.										
Switches to Annunciator.										
Interlocking Circuit.										
Controller to Valve.										
Controller Action D or R.										

REMARKS:

READY FOR START-UP

Date: _____

Installed by: _____

Checked by:

END OF SECTION

SECTION 40 61 21

PROCESS CONTROL SYSTEM TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide Control System Site Acceptance Testing as specified in this section and in compliance with the Contract Documents. The purpose of the site acceptance testing is to demonstrate the performance of the process control system by testing all components and functions of the system. The test will be conducted in three phases:
 - 1. Component testing: Demonstrate in manual mode that each connected component of the control system functions in accordance with specifications and manufacturer requirements. Demonstrate that field device inputs and outputs for the control system are functioning properly with correct polarity and scaling.
 - 2. PLC Area Acceptance Testing: Demonstrate the key data acquisition, control strategies, interlocks, and alarm functions for each process area in manual, semi-automatic, and automatic control modes as applicable. Coordinate and cooperate with other divisions and simulate and/or force key process variables as required to facilitate testing activities.
 - 3. Overall Integrated System Performance Testing: In cooperation with other divisions, participate in the Overall Integrated Performance Tests specified in the process and mechanical divisions.

1.02 REFERENCES:

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging
 - 2. S5.4: Instrument Loop Diagrams
 - 3. S7: Instrument Air
 - 4. S12: Electrical Equipment for Hazardous Locations
 - 5. S18.2: Alarm Management
 - 6. S20: Instrument Specifications
 - 7. S50: Electrical Control Signals
 - 8. S75: Control Valve Design, Specification and Testing

- 9. S96: Valve Actuators
- 10. S99: Control System Cyber Security
- 11. 101: Human-Machine Interfaces

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Process methodology statement stating how and what will be done by the Contractor during the acceptance testing. The methodology statement will be prepared by the Contractor with the Engineer providing reviews and input and must be approved before implementation.
 - 2. Test schedule for each Component, Process Unit, and Process Area.
 - 3. Process control system component test procedures.
 - 4. Process Area control strategy test procedures.
 - 5. Integrated System Performance Test procedures.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Within two (2) weeks following completion of any acceptance tests, submit acceptance test report to the Engineer.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.07 PROJECT/SITE CONDITIONS:

- A. Coordinate all work of this Section with the Other Contractors responsible for the construction of the related work, with plant operations and the Engineer.

1.08 WARRANTY:

- A. As specified in Division 01.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Provide any and all software, tools, testing equipment, temporary configuration programs, cables, wiring, terminals and other accessories required to fully test and verify the proper connection and operation the process control system.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Meet the following conditions prior to the start of any acceptance testing.
 - 1. Correct deficiencies noted during installation prior to commencement of testing.
 - 2. Have on site, documentation pertinent to the equipment being tested. Provide a detailed description of the testing methodology to be used to ensure satisfactory performance of the process control system equipment.
 - 3. Keep on site, labelled, and properly stored spare parts, expendables and test equipment pertinent to the equipment being tested.
 - 4. Have the Engineer review acceptance test schedules and acceptance test procedures.
 - 5. Perform the acceptance testing on a per Process Area basis. Test no more than one Process Area at any given time unless other arrangements are made with the Engineer.
 - 6. Obtain approval from the Engineer prior to conducting any testing which may affect existing operations.
 - 7. Schedule any testing which affects the system operation through the Engineer daily.

3.02 FIELD TESTING:

- A. Organize acceptance testing sequentially by Process Area and in line with the master schedule. Include testing of all inputs/outputs (I/Os), PLC functions and communications for each Process Area and vendor-supplied equipment components.
- B. Check each Process Area against drawings and database lists. Test each PLC and corresponding data communication links.
- C. Check all I/O from the field components to the process control system. Include instruments, control devices, panels, termination cabinets, input/output cards, and other devices in the I/O to ensure proper operation. The applicable Other Contractor will be in attendance during I/O field checks.

D. Document the component testing and submit to the Engineer. Include the following:

1. I/O name.
2. I/O description.
3. Drawing reference.
4. Type of test(s) performed.
5. Date tested.
6. Signature of tester and date.
7. Signature of Engineer and date.

E. Test the process control system equipment as follows:

1. Check equipment against inventory lists.
2. Certify that the equipment has been installed properly.
3. Power up the process control system equipment and run diagnostics to verify proper operation.
4. Load the application system software from backup media.
5. Verify peripheral operation and peripheral failure operation.
6. Check polling of remotes.
7. Verify that data is not lost on failover from the primary to the backup communication path.
8. Verify that operating data is not lost on failover from the primary to the standby processor.
9. Verify historical data is not lost if the system server is down for less than 72 hours.
10. Test input/output, display, control, and report generation software.
11. Test historical data collection capabilities.
12. Test trending functions.
13. Certify that the system is ready for performance testing.
14. Test operation of the Local Area Network associated with the process control system equipment.

15. Test all alarm functions and alarm history files.
 16. Test system automatic backup and restore procedures.
- F. Document the process control system area testing and submit to the Engineer. Include the following:
1. Description of functions tested.
 2. Tests performed.
 3. Copies of messages, displays, reports, and trends which verify operation.
 4. Signature of tester and date.
 5. Signature of the Engineer and date.
 6. Problem description, if any.
 7. Performance Verification.
- G. After Process Area Testing and component testing have been completed, perform an Integrated System Performance Test to verify the system performance. Provide onsite personnel for the Integrated System Performance Test duration.
- 3.03 DEMONSTRATION:
- A. Use the communications statistics to verify and demonstrate that the average process control system equipment to PLC communications availability is greater than 99.99%. Failure of data communication equipment will not count as downtime.
- B. Demonstrate an availability of 99.99% or better for the entire process control system. Availability is defined as:
1. $\text{Availability} = (\text{Test Duration} - \text{Downtime}) / \text{Test Duration}$.
- C. The system is down if a PLC cannot be accessed from the operator station because of a hardware/software failure, an operational PLC is not polled, alarm and event reporting functions are lost, trend or historical data is lost, or operator commands cannot be carried out because of a hardware/software failure.
- D. Failover to a backup device will not be counted as downtime provided the backup device assumed proper operation.
- E. Demonstrate the historical logging and reporting functions of the system.
- F. Demonstrate system response times for operator displays and data update to or from other process areas and remote sites. Perform test reruns the Engineer may deem necessary.

3.04 PROTECTION:

- A. Operate control system equipment only in areas where construction is sufficiently completed and with environmental controls in place and operational such that the manufacturer's environmental requirements are not compromised.
- B. Provide dust and moisture protection for control system equipment overnight and when not in use to protect against unanticipated construction activities, painting, cleaning, etc.
- C. Maintain daily backups of all program and configuration files for all control system components on removeable media. Backup files may be stored off-site or on-site provided that they are physically separated from the respective control system equipment.

3.05 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 61 93

PROCESS CONTROL SYSTEM INPUT/OUTPUT LIST

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The control system I/O indices included in this section have been provided for reference and includes all the control system input and output points shown on the P&ID drawings and the mechanical system schematics. The control system I/O indices will be used by the control system programmers and integrators to develop the control system PLC application programs, server and historian computer configurations, and Human-Machine Interface graphics.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging
 - 2. S5.4: Instrument Loop Diagrams
 - 3. S7: Instrument Air
 - 4. S12: Electrical Equipment for Hazardous Locations
 - 5. S18.2: Alarm Management
 - 6. S20: Instrument Specifications
 - 7. S50: Electrical Control Signals
 - 8. S75: Control Valve Design, Specification and Testing
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security
 - 11. 101: Human-Machine Interfaces

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. The Input/Output indices provided in this section shall be updated by the contractor based on the finalized Input/Output requirements for each packaged system and piece of equipment obtained from the approved shop drawings.

2. Submit finalized For Construction Input/Output indices for the process control system when all shop drawings have been reviewed.
3. Submit As-Constructed Input/Output indices for the entire control system for review when construction and commission is completed.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 GENERAL

- A. Update Input/Output indices provided in this section based on the finalized Input/Output requirements for each packaged system and piece of equipment obtained from the approved shop drawings.
- B. Use only updated and reviewed Input/Output lists in the development of the control system PLC application programs, server and historian computer configurations, and Human-Machine Interface graphics.
- C. Submit the As-Constructed Input/Output indices for review by the Engineer and include copies in the project O&M manuals in both printed and soft copies on removable media.

3.02 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

Process Control System Input Output List

Tag	P&ID	Description	PLC/Control Panel	I/O Type	Range	Notes
P25-AI-0102-1	01-X601	Future Analysis Indication	N/A		N/A	Future I/O Point - By Others
P25-LI-0102-1	01-X601	Raw Water Diversion Box Level	PLC-0000-1	AI	0 - 10 FT	
P25-FI-0102-2	01-X601	Raw Water Irrigation Pump Discharge Flow	PLC-0000-1	AI	0 - 30 GPM	
P25-LAHH-0102-1	01-X601	Coagulant Injection Vault Level Alarm High High	PLC-0000-1	DI	Bool	
P25-IR-0102-1A	01-X601	Raw Water Diversion Box Plant Influent Slide Gate In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0102-1A	01-X601	Raw Water Diversion Box Plant Influent Slide Gate Closed	PLC-0000-1	DI	Bool	
P25-ZIO-0102-1A	01-X601	Coagulant Injection Vault Hatch Position Open	PLC-0000-1	DI	Bool	
P25-ZF-0102-1A	01-X601	Raw Water Diversion Box Plant Influent Slide Gate Fault	PLC-0000-1	DI	Bool	
P25-ZH-0102-1A	01-X601	Raw Water Diversion Box Plant Influent Slide Gate Open	PLC-0000-1	DI	Bool	
P25-ZF-0102-1B	01-X601	Raw Water Diversion Box Mill Race Canal Slide Gate Fault	PLC-0000-1	DI	Bool	
P25-ZIO-0102-1B	01-X601	Coagulant Injection Vault Hatch Position Open	PLC-0000-1	DI	Bool	
P25-ZL-0102-1B	01-X601	Raw Water Diversion Box Mill Race Canal Slide Gate Closed	PLC-0000-1	DI	Bool	
P25-IR-0102-1B	01-X601	Raw Water Diversion Box Mill Race Canal Slide Gate In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0102-1B	01-X601	Raw Water Diversion Box Mill Race Canal Slide Gate Open	PLC-0000-1	DI	Bool	
P25-ZD-0102-1A	01-X601	Raw Water Diversion Box Plant Influent Slide Gate Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0102-1A	01-X601	Raw Water Diversion Box Plant Influent Slide Gate Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0102-1B	01-X601	Raw Water Diversion Box Mill Race Canal Slide Gate Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0102-1B	01-X601	Raw Water Diversion Box Mill Race Canal Slide Gate Command Open	PLC-0000-1	DO	1 = Open	
P25-FI-0101-1	05-X601	Raw Water Diversion Wet Well Effluent Flow	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-MN-0101-1	05-X601	Raw Water Diversion Wet Well Intake Screen Running	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-MF-0101-1	05-X601	Raw Water Diversion Wet Well Intake Screen Fault	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-MD-0101-1	05-X601	Raw Water Diversion Wet Well Intake Screen Command Start	Existing RTU	ETH	1 = Start	Integrate existing Ethernet I/O point via City network
P25-LI-0101-1A	05-X601	Raw Water Diversion Wet Well Intake Screen Upstream Level	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-ZD-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate Command Open	Existing RTU	ETH	1 = Open	Integrate existing Ethernet I/O point via City network
P25-IR-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate In Remote	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-ZF-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate Actuator Fault	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-ZH-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate Open	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-ZB-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate Command Close	Existing RTU	ETH	1 = Close	Integrate existing Ethernet I/O point via City network
P25-ZI-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate Position	Existing RTU	ETH	0 - 100%	Integrate existing Ethernet I/O point via City network
P25-ZL-0101-1A	05-X601	Raw Water Diversion Wet Well Effluent Slide Gate Closed	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-AI-0101-1AA	05-X601	Raw Water Diversion Wet Well BOD	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-AI-0101-1AB	05-X601	Raw Water Diversion Wet Well BOD	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-AI-0101-1AC	05-X601	Raw Water Diversion Wet Well DOC	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-AI-0101-1AD	05-X601	Raw Water Diversion Wet Well TOC	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-AI-0101-1AE	05-X601	Raw Water Diversion Wet Well NO3	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-AI-0101-1B	05-X601	Raw Water Diversion Wet Well Turbidity	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-LI-0101-1B	05-X601	Raw Water Diversion Wet Well Intake Screen Downstream Level	Existing RTU	ETH	By Vendor	Integrate existing Ethernet I/O point via City network
P25-ZH-0101-3	05-X601	Raw Water Radial Gate Open	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-ZF-0101-3	05-X601	Raw Water Radial Gate Actuator Fault	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-IR-0101-3	05-X601	Raw Water Radial Gate In Remote	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-ZI-0101-3	05-X601	Raw Water Radial Gate Position	Existing RTU	ETH	0 - 100%	Integrate existing Ethernet I/O point via City network

P25-ZB-0101-3	05-X601	Raw Water Radial Gate Command Close	Existing RTU	ETH	1 = Close	Integrate existing Ethernet I/O point via City network
P25-ZD-0101-3	05-X601	Raw Water Radial Gate Command Open	Existing RTU	ETH	1 = Open	Integrate existing Ethernet I/O point via City network
P25-ZL-0101-3	05-X601	Raw Water Radial Gate Open	Existing RTU	ETH	Bool	Integrate existing Ethernet I/O point via City network
P25-PI-0303-1	10-X601	Raw Water Plant Influent Pressure	PLC-0000-1	AI	0 - 15 PSI	
P25-FI-0302-1	10-X601	Coagulant Flash Mix to In-Line Flash Reactor Flow	PLC-0000-1	AI	0 - 2000 GPM	
P25-FI-0303-1	10-X601	Raw Water Plant Influent Flow	PLC-0000-1	AI	0 - 21000 GPM	
P25-AI-0303-1A	10-X601	Raw Water Plant Influent Turbidity	PLC-0000-1	AI	0.0 - 100.0 NTU	
P25-AI-0303-1B	10-X601	Raw Water Plant Influent pH	PLC-0000-1	AI	0.0 - 14.0	
P25-SI-0302-5	10-X601	Coagulant Flash Mix Pump 1 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0302-6	10-X601	Coagulant Flash Mix Pump 2 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0302-5	10-X601	Coagulant Flash Mix Pump 1 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0302-6	10-X601	Coagulant Flash Mix Pump 2 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-PAL-0302-5	10-X601	Coagulant Flash Mix Pump 1 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MN-0302-5	10-X601	Coagulant Flash Mix Pump 1 Running	RIO-0000-1	DI	Bool	
P25-MY-0302-5	10-X601	Coagulant Flash Mix Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0302-5	10-X601	Coagulant Flash Mix Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-XF-0302-5	10-X601	Coagulant Flash Mix Pump 1 VFD Fault	RIO-0000-1	DI	Bool	
P25-XF-0302-6	10-X601	Coagulant Flash Mix Pump 2 VFD Fault	RIO-0000-1	DI	Bool	
P25-IR-0302-6	10-X601	Coagulant Flash Mix Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0302-6	10-X601	Coagulant Flash Mix Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MN-0302-6	10-X601	Coagulant Flash Mix Pump 2 Running	RIO-0000-1	DI	Bool	
P25-PAL-0302-6	10-X601	Coagulant Flash Mix Pump 2 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MO-0302-5	10-X601	Coagulant Flash Mix Pump 1 Overload Fault	RIO-0000-1	DO	Bool	
P25-MD-0302-5	10-X601	Coagulant Flash Mix Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0302-6	10-X601	Coagulant Flash Mix Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-MO-0302-6	10-X601	Coagulant Flash Mix Pump 2 Overload Fault	RIO-0000-1	DO	Bool	
P25-SI-0202-1	10-X602	UF Feed Pump 2 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0203-1	10-X602	UF Feed Pump 3 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0201-1	10-X602	UF Feed Pump 1 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0201-1	10-X602	UF Feed Pump 1 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0202-1	10-X602	UF Feed Pump 2 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0203-1	10-X602	UF Feed Pump 3 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-MN-0202-1	10-X602	UF Feed Pump 2 Running	RIO-0000-1	DI	Bool	
P25-XF-0202-1	10-X602	UF Feed Pump 2 VFD Fault	RIO-0000-1	DI	Bool	
P25-IR-0203-1	10-X602	UF Feed Pump 3 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0203-1	10-X602	UF Feed Pump 3 Running	RIO-0000-1	DI	Bool	
P25-MN-0201-1	10-X602	UF Feed Pump 1 Running	RIO-0000-1	DI	Bool	
P25-MY-0203-1	10-X602	UF Feed Pump 3 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MO-0201-1	10-X602	UF Feed Pump 1 Overload Fault	RIO-0000-1	DI	Bool	
P25-XF-0203-1	10-X602	UF Feed Pump 3 VFD Fault	RIO-0000-1	DI	Bool	
P25-MY-0201-1	10-X602	UF Feed Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-PAL-0202-1	10-X602	UF Feed Pump 2 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-IR-0202-1	10-X602	UF Feed Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-PAL-0203-1	10-X602	UF Feed Pump 3 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MO-0203-1	10-X602	UF Feed Pump 3 Overload Fault	RIO-0000-1	DI	Bool	
P25-MO-0202-1	10-X602	UF Feed Pump 2 Overload Fault	RIO-0000-1	DI	Bool	
P25-XF-0201-1	10-X602	UF Feed Pump 1 VFD Fault	RIO-0000-1	DI	Bool	
P25-MY-0202-1	10-X602	UF Feed Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-PAL-0201-1	10-X602	UF Feed Pump 1 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	

P25-IR-0201-1	10-X602	UF Feed Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-IR-0203-2	10-X602	UF Strainer 3 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0202-2	10-X602	UF Strainer 2 Running	RIO-0000-1	DI	Bool	
P25-IR-0201-2	10-X602	UF Strainer 1 In Remote	RIO-0000-1	DI	Bool	
P25-DPAH-0202-2	10-X602	UF Strainer 2 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MN-0201-2	10-X602	UF Strainer 1 Running	RIO-0000-1	DI	Bool	
P25-DPAH-0203-2	10-X602	UF Strainer 3 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MO-0201-2	10-X602	UF Strainer 1 Overload Fault	RIO-0000-1	DI	Bool	
P25-MN-0203-2	10-X602	UF Strainer 3 Running	RIO-0000-1	DI	Bool	
P25-MO-0203-2	10-X602	UF Strainer 3 Overload Fault	RIO-0000-1	DI	Bool	
P25-MO-0202-2	10-X602	UF Strainer 2 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0202-2	10-X602	UF Strainer 2 In Remote	RIO-0000-1	DI	Bool	
P25-DPAH-0201-2	10-X602	UF Strainer 1 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-ZF-0202-2A	10-X602	UF Strainer 2 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0203-2A	10-X602	UF Strainer 3 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0202-2A	10-X602	UF Strainer 2 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0203-2A	10-X602	UF Strainer 3 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0201-2A	10-X602	UF Strainer 1 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-IR-0202-2A	10-X602	UF Strainer 2 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0201-2A	10-X602	UF Strainer 1 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0201-2A	10-X602	UF Strainer 1 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0202-2A	10-X602	UF Strainer 2 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0203-2A?	10-X602	UF Strainer 3 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZL-0201-2A	10-X602	UF Strainer 1 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZL-0203-2A?	10-X602	UF Strainer 3 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-MD-0201-1	10-X602	UF Feed Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0202-1	10-X602	UF Feed Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0203-1	10-X602	UF Feed Pump 3 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0203-2	10-X602	UF Strainer 3 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0202-2	10-X602	UF Strainer 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0201-2	10-X602	UF Strainer 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZD-0203-2A	10-X602	UF Strainer 3 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0202-2A	10-X602	UF Strainer 2 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0203-2A	10-X602	UF Strainer 3 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0202-2A	10-X602	UF Strainer 2 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0201-2A	10-X602	UF Strainer 1 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0201-2A	10-X602	UF Strainer 1 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-SI-0205-1	10-X603	UF Feed Pump 5 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0204-1	10-X603	UF Feed Pump 4 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0207-1	10-X603	UF Feed Pump 7 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0207-1	10-X603	UF Feed Pump 7 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0204-1	10-X603	UF Feed Pump 4 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0205-1	10-X603	UF Feed Pump 5 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-MO-0207-1	10-X603	UF Feed Pump 7 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0205-1	10-X603	UF Feed Pump 5 In Remote	RIO-0000-1	DI	Bool	
P25-MO-0204-1	10-X603	UF Feed Pump 4 Overload Fault	RIO-0000-1	DI	Bool	
P25-PAL-0204-1	10-X603	UF Feed Pump 4 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MO-0205-1	10-X603	UF Feed Pump 5 Overload Fault	RIO-0000-1	DI	Bool	
P25-MY-0204-1	10-X603	UF Feed Pump 4 Emergency Stop	RIO-0000-1	DI	Bool	

P25-PAL-0207-1	10-X603	UF Feed Pump 7 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-IR-0204-1	10-X603	UF Feed Pump 4 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0204-1	10-X603	UF Feed Pump 4 Running	RIO-0000-1	DI	Bool	
P25-XF-0204-1	10-X603	UF Feed Pump 4 VFD Fault	RIO-0000-1	DI	Bool	
P25-MN-0207-1	10-X603	UF Feed Pump 7 Running	RIO-0000-1	DI	Bool	
P25-IR-0207-1	10-X603	UF Feed Pump 7 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0205-1	10-X603	UF Feed Pump 5 Running	RIO-0000-1	DI	Bool	
P25-XF-0205-1	10-X603	UF Feed Pump 5 VFD Fault	RIO-0000-1	DI	Bool	
P25-MY-0207-1	10-X603	UF Feed Pump 7 Emergency Stop	RIO-0000-1	DI	Bool	
P25-XF-0207-1	10-X603	UF Feed Pump 7 VFD Fault	RIO-0000-1	DI	Bool	
P25-MY-0205-1	10-X603	UF Feed Pump 5 Emergency Stop	RIO-0000-1	DI	Bool	
P25-PAL-0205-1	10-X603	UF Feed Pump 5 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MO-0205-2	10-X603	UF Strainer 5 Overload Fault	RIO-0000-1	DI	Bool	
P25-DPAH-0204-2	10-X603	UF Strainer 4 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-DPAH-0207-2	10-X603	UF Strainer 7 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0205-2	10-X603	UF Strainer 5 In Remote	RIO-0000-1	DI	Bool	
P25-MO-0204-2	10-X603	UF Strainer 4 Overload Fault	RIO-0000-1	DI	Bool	
P25-MN-0207-2	10-X603	UF Strainer 7 Running	RIO-0000-1	DI	Bool	
P25-MN-0204-2	10-X603	UF Strainer 4 Running	RIO-0000-1	DI	Bool	
P25-MO-0207-2	10-X603	UF Strainer 7 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0204-2	10-X603	UF Strainer 4 In Remote	RIO-0000-1	DI	Bool	
P25-DPAH-0205-2	10-X603	UF Strainer 5 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0207-2	10-X603	UF Strainer 7 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0205-2	10-X603	UF Strainer 5 Running	RIO-0000-1	DI	Bool	
P25-ZH-0205-2A	10-X603	UF Strainer 5 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZH-0207-2A	10-X603	UF Strainer 7 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0207-2A	10-X603	UF Strainer 7 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZL-0207-2A	10-X603	UF Strainer 7 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZL-0205-2A	10-X603	UF Strainer 5 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZL-0204-2A	10-X603	UF Strainer 4 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0204-2A	10-X603	UF Strainer 4 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-IR-0205-2A	10-X603	UF Strainer 5 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0204-2A	10-X603	UF Strainer 4 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0204-2A	10-X603	UF Strainer 4 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZF-0205-2A	10-X603	UF Strainer 5 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0207-2A	10-X603	UF Strainer 7 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-MD-0207-1	10-X603	UF Feed Pump 7 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0205-1	10-X603	UF Feed Pump 5 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0204-1	10-X603	UF Feed Pump 4 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0205-2	10-X603	UF Strainer 5 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0204-2	10-X603	UF Strainer 4 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0207-2	10-X603	UF Strainer 7 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZD-0205-2A	10-X603	UF Strainer 5 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0204-2A	10-X603	UF Strainer 4 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0205-2A	10-X603	UF Strainer 5 Discharge Valve Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZB-0207-2A	10-X603	UF Strainer 7 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0207-2A	10-X603	UF Strainer 7 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0204-2A	10-X603	UF Strainer 4 Discharge Valve Command Closed	PLC-0000-1	DO	1 = Close	
P25-SI-0209-1	10-X604	UF Feed Pump 9 Speed Indication	RIO-0000-1	AI	0 - 100%	

P25-SI-0208-1	10-X604	UF Feed Pump 8 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0206-1	10-X604	UF Feed Pump 6 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0206-1	10-X604	UF Feed Pump 6 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0208-1	10-X604	UF Feed Pump 8 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0209-1	10-X604	UF Feed Pump 9 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-IR-0208-1	10-X604	UF Feed Pump 8 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0209-1	10-X604	UF Feed Pump 9 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MN-0206-1	10-X604	UF Feed Pump 6 Running	RIO-0000-1	DI	Bool	
P25-MN-0208-1	10-X604	UF Feed Pump 8 Running	RIO-0000-1	DI	Bool	
P25-MO-0208-1	10-X604	UF Feed Pump 8 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0206-1	10-X604	UF Feed Pump 6 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0206-1	10-X604	UF Feed Pump 6 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0209-1	10-X604	UF Feed Pump 9 In Remote	RIO-0000-1	DI	Bool	
P25-MO-0209-1	10-X604	UF Feed Pump 9 Overload Fault	RIO-0000-1	DI	Bool	
P25-MN-0209-1	10-X604	UF Feed Pump 9 Running	RIO-0000-1	DI	Bool	
P25-PAL-0206-1	10-X604	UF Feed Pump 6 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-XF-0206-1	10-X604	UF Feed Pump 6 VFD Fault	RIO-0000-1	DI	Bool	
P25-PAL-0208-1	10-X604	UF Feed Pump 8 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MY-0208-1	10-X604	UF Feed Pump 8 Emergency Stop	RIO-0000-1	DI	Bool	
P25-XF-0209-1	10-X604	UF Feed Pump 9 VFD Fault	RIO-0000-1	DI	Bool	
P25-XF-0208-1	10-X604	UF Feed Pump 8 VFD Fault	RIO-0000-1	DI	Bool	
P25-MO-0206-1	10-X604	UF Feed Pump 6 Overload Fault	RIO-0000-1	DI	Bool	
P25-PAL-0209-1	10-X604	UF Feed Pump 9 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-IR-0206-2	10-X604	UF Strainer 6 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0209-2	10-X604	UF Strainer 9 Running	RIO-0000-1	DI	Bool	
P25-MO-0209-2	10-X604	UF Strainer 9 Overload Fault	RIO-0000-1	DI	Bool	
P25-DPAH-0208-2	10-X604	UF Strainer 8 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MN-0208-2	10-X604	UF Strainer 8 Running	RIO-0000-1	DI	Bool	
P25-DPAH-0209-2	10-X604	UF Strainer 9 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MN-0206-2	10-X604	UF Strainer 6 Running	RIO-0000-1	DI	Bool	
P25-IR-0209-2	10-X604	UF Strainer 9 In Remote	RIO-0000-1	DI	Bool	
P25-IR-0208-2	10-X604	UF Strainer 8 In Remote	RIO-0000-1	DI	Bool	
P25-MO-0208-2	10-X604	UF Strainer 8 Overload Fault	RIO-0000-1	DI	Bool	
P25-DPAH-0206-2	10-X604	UF Strainer 6 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MO-0206-2	10-X604	UF Strainer 6 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0208-2A	10-X604	UF Strainer 8 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0209-2A	10-X604	UF Strainer 9 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZF-0209-2A	10-X604	UF Strainer 9 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0206-2A	10-X604	UF Strainer 6 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZH-0209-2A	10-X604	UF Strainer 9 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZL-0208-2A	10-X604	UF Strainer 8 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZL-0206-2A	10-X604	UF Strainer 6 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0209-2A	10-X604	UF Strainer 9 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0208-2A	10-X604	UF Strainer 8 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZF-0206-2A	10-X604	UF Strainer 6 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0208-2A	10-X604	UF Strainer 8 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-IR-0206-2A	10-X604	UF Strainer 6 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-MD-0209-1	10-X604	UF Feed Pump 9 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0208-1	10-X604	UF Feed Pump 8 Command Start	RIO-0000-1	DO	1 = Start	

P25-MD-0206-1	10-X604	UF Feed Pump 6 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0206-2	10-X604	UF Strainer 6 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0208-2	10-X604	UF Strainer 8 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0209-2	10-X604	UF Strainer 9 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZB-0209-2A	10-X604	UF Strainer 9 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0206-2A	10-X604	UF Strainer 6 Discharge Valve Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZB-0208-2A	10-X604	UF Strainer 8 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0206-2A	10-X604	UF Strainer 6 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0209-2A	10-X604	UF Strainer 9 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0208-2A	10-X604	UF Strainer 8 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-SI-0210-1	10-X605	UF Feed Pump 10 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0213-1	10-X605	UF Feed Pump 13 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0211-1	10-X605	UF Feed Pump 11 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0210-1	10-X605	UF Feed Pump 10 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0213-1	10-X605	UF Feed Pump 13 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0211-1	10-X605	UF Feed Pump 11 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-XF-0210-1	10-X605	UF Feed Pump 10 VFD Fault	RIO-0000-1	DI	Bool	
P25-PAL-0211-1	10-X605	UF Feed Pump 11 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MY-0213-1	10-X605	UF Feed Pump 13 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MN-0211-1	10-X605	UF Feed Pump 11 Running	RIO-0000-1	DI	Bool	
P25-MO-0213-1	10-X605	UF Feed Pump 13 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0211-1	10-X605	UF Feed Pump 11 In Remote	RIO-0000-1	DI	Bool	
P25-XF-0213-1	10-X605	UF Feed Pump 13 VFD Fault	RIO-0000-1	DI	Bool	
P25-PAL-0213-1	10-X605	UF Feed Pump 13 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-XF-0211-1	10-X605	UF Feed Pump 11 VFD Fault	RIO-0000-1	DI	Bool	
P25-MO-0210-1	10-X605	UF Feed Pump 10 Overload Fault	RIO-0000-1	DI	Bool	
P25-IR-0210-1	10-X605	UF Feed Pump 10 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0213-1	10-X605	UF Feed Pump 13 Running	RIO-0000-1	DI	Bool	
P25-MO-0211-1	10-X605	UF Feed Pump 11 Overload Fault	RIO-0000-1	DI	Bool	
P25-MY-0210-1	10-X605	UF Feed Pump 10 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0213-1	10-X605	UF Feed Pump 13 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0211-1	10-X605	UF Feed Pump 11 Emergency Stop	RIO-0000-1	DI	Bool	
P25-PAL-0210-1	10-X605	UF Feed Pump 10 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MN-0210-1	10-X605	UF Feed Pump 10 Running	RIO-0000-1	DI	Bool	
P25-MN-0210-2	10-X605	UF Strainer 10 Running	RIO-0000-1	DI	Bool	
P25-IR-0213-2	10-X605	UF Strainer 13 In Remote	RIO-0000-1	DI	Bool	
P25-DPAH-0210-2	10-X605	UF Strainer 10 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MN-0213-2	10-X605	UF Strainer 13 Running	RIO-0000-1	DI	Bool	
P25-MO-0213-2	10-X605	UF Strainer 13 Overload Fault	RIO-0000-1	DI	Bool	
P25-MO-0210-2	10-X605	UF Strainer 10 Overload Fault	RIO-0000-1	DI	Bool	
P25-MN-0211-2	10-X605	UF Strainer 11 Running	RIO-0000-1	DI	Bool	
P25-DPAH-0211-2	10-X605	UF Strainer 11 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MO-0211-2	10-X605	UF Strainer 11 Overload Fault	RIO-0000-1	DI	Bool	
P25-DPAH-0213-2	10-X605	UF Strainer 13 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0210-2	10-X605	UF Strainer 10 In Remote	RIO-0000-1	DI	Bool	
P25-IR-0211-2	10-X605	UF Strainer 11 In Remote	RIO-0000-1	DI	Bool	
P25-ZF-0210-2A	10-X605	UF Strainer 10 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0211-2A	10-X605	UF Strainer 11 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZL-0211-2A	10-X605	UF Strainer 11 Discharge Valve Closed	PLC-0000-1	DI	Bool	

P25-ZL-0210-2A	10-X605	UF Strainer 10 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0213-2A	10-X605	UF Strainer 13 Drain Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0211-2A	10-X605	UF Strainer 11 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZL-0213-2A	10-X605	UF Strainer 13 Drain Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0211-2A	10-X605	UF Strainer 11 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0213-2A	10-X605	UF Strainer 13 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0210-2A	10-X605	UF Strainer 10 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0213-2A	10-X605	UF Strainer 13 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZH-0210-2A	10-X605	UF Strainer 10 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-MD-0211-1	10-X605	UF Feed Pump 11 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0210-1	10-X605	UF Feed Pump 10 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0213-1	10-X605	UF Feed Pump 13 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0211-2	10-X605	UF Strainer 11 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0213-2	10-X605	UF Strainer 13 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0210-2	10-X605	UF Strainer 10 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZD-0213-2A	10-X605	UF Strainer 13 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0210-2A	10-X605	UF Strainer 10 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0213-2A	10-X605	UF Strainer 13 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0211-2A	10-X605	UF Strainer 11 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0210-2A	10-X605	UF Strainer 10 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0211-2A	10-X605	UF Strainer 11 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-SI-0212-1	10-X606	UF Feed Pump 12 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0212-1	10-X606	UF Feed Pump 12 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-MY-0212-1	10-X606	UF Feed Pump 12 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MO-0212-1	10-X606	UF Feed Pump 12 Overload Fault	RIO-0000-1	DI	Bool	
P25-PAL-0212-1	10-X606	UF Feed Pump 12 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MN-0212-1	10-X606	UF Feed Pump 12 Running	RIO-0000-1	DI	Bool	
P25-XF-0212-1	10-X606	UF Feed Pump 12 VFD Fault	RIO-0000-1	DI	Bool	
P25-IR-0212-1	10-X606	UF Feed Pump 12 In Remote	RIO-0000-1	DI	Bool	
P25-DPAH-0212-2	10-X606	UF Strainer 12 Differential Presure Alarm High	PLC-0000-1	DI	Bool	
P25-MO-0212-2	10-X606	UF Strainer 12 Overload Fault	RIO-0000-1	DI	Bool	
P25-MN-0212-2	10-X606	UF Strainer 12 Running	RIO-0000-1	DI	Bool	
P25-IR-0212-2	10-X606	UF Strainer 12 In Remote	RIO-0000-1	DI	Bool	
P25-IR-0212-2A	10-X606	UF Strainer 12 Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0212-2A	10-X606	UF Strainer 12 Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0212-2A	10-X606	UF Strainer 12 Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZL-0212-2A	10-X606	UF Strainer 12 Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-MD-0212-1	10-X606	UF Feed Pump 12 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0212-2	10-X606	UF Strainer 12 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZB-0212-2A	10-X606	UF Strainer 12 Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0212-2A	10-X606	UF Strainer 12 Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-HC-0200-1	10-X607	UF System Command Start	MCP-0200-1	ETH	By Vendor	
P25-XA-0200-1	10-X607	UF System General Alarm	MCP-0200-1	ETH	By Vendor	
P25-PDI-0203-1	10-X607	UF Skid 1 Transmembrane Pressure	LCP-0203-1	ETH	By Vendor	
P25-XA-0203-1	10-X607	UF Skid 1 General Alarm	LCP-0203-1	ETH	By Vendor	
P25-FI-0203-1	10-X607	UF Skid 1 Filtrate Flow	LCP-0203-1	ETH	By Vendor	
P25-TI-0203-1	10-X607	UF Skid 1 Water Temperature	LCP-0203-1	ETH	By Vendor	
P25-AI-0203-1A	10-X607	UF Skid 1 Normalized Permeability	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1A	10-X607	UF Skid 1 in Production Mode	LCP-0203-1	ETH	By Vendor	

P25-ZH-0203-1A	10-X607	UF Skid 1 UF Feed Block Valve Open	LCP-0203-1	ETH	By Vendor	
P25-PI-0203-1A	10-X607	UF Skid 1 Feed Pressure	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1A	10-X607	UF Skid 1 UF Feed Block Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1B	10-X607	UF Skid 1 in Backwash Mode	LCP-0203-1	ETH	By Vendor	
P25-PI-0203-1B	10-X607	UF Skid 1 Filtrate Pressure	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1B	10-X607	UF Skid 1 UF Feed Valve Open	LCP-0203-1	ETH	By Vendor	
P25-AI-0203-1B	10-X607	UF Skid 1 Membrane Flux	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1B	10-X607	UF Skid 1 UF Feed Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1C	10-X607	UF Skid 1 in Maintenance Clean Mode	LCP-0203-1	ETH	By Vendor	
P25-AI-0203-1C	10-X607	UF Skid 1 Filtrate Turbidity	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1C	10-X607	UF Skid 1 UF Feed Drain Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1C	10-X607	UF Skid 1 UF Feed Drain Valve Open	LCP-0203-1	ETH	By Vendor	
P25-PI-0203-1C	10-X607	UF Skid 1 Air System Pressure	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1D	10-X607	UF Skid 1 CIP Supply Block Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1D	10-X607	UF Skid 1 in CIP Mode	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1D	10-X607	UF Skid 1 CIP Supply Block Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1E	10-X607	UF Skid 1 CIP Supply Valve Open	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1E	10-X607	UF Skid 1 Integrity Test	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1E	10-X607	UF Skid 1 CIP Supply Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1F	10-X607	UF Skid 1 CIP Supply Drain Valve Open	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1F	10-X607	UF Skid 1 in Standby	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1F	10-X607	UF Skid 1 CIP Supply Drain Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1G	10-X607	UF Skid 1 Backwash Supply Block Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1G	10-X607	UF Skid 1 Backwash Supply Block Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-YI-0203-1G	10-X607	UF Skid 1 Offline	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1H	10-X607	UF Skid 1 Backwash Supply Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1H	10-X607	UF Skid 1 Backwash Supply Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1I	10-X607	UF Skid 1 Backwash Supply Drain Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1I	10-X607	UF Skid 1 Backwash Supply Drain Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1J	10-X607	UF Skid 1 UF Filtrate Block Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1J	10-X607	UF Skid 1 UF Filtrate Block Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1K	10-X607	UF Skid 1 UF Filtrate Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1K	10-X607	UF Skid 1 UF Filtrate Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1L	10-X607	UF Skid 1 UF Filtrate Drain Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1L	10-X607	UF Skid 1 UF Filtrate Drain Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1M	10-X607	UF Skid 1 UF Filtrate CIP Return Block Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1M	10-X607	UF Skid 1 UF Filtrate CIP Return Block Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1N	10-X607	UF Skid 1 UF Filtrate CIP Return Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1N	10-X607	UF Skid 1 UF Filtrate CIP Return Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1O	10-X607	UF Skid 1 UF Filtrate CIP Return Drain Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1O	10-X607	UF Skid 1 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1P	10-X607	UF Skid 1 Backwash Waste CIP Return Block Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1P	10-X607	UF Skid 1 Backwash Waste CIP Return Block Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1Q	10-X607	UF Skid 1 Backwash Waste CIP Return Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1Q	10-X607	UF Skid 1 Backwash Waste CIP Return Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1R	10-X607	UF Skid 1 Backwash Waste CIP Return Drain Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1R	10-X607	UF Skid 1 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1S	10-X607	UF Skid 1 Backwash Waste Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1S	10-X607	UF Skid 1 Backwash Waste Valve Closed	LCP-0203-1	ETH	By Vendor	

P25-ZL-0203-1T	10-X607	UF Skid 1 UF Filtrate Air Purge Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1T	10-X607	UF Skid 1 UF Filtrate Air Purge Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1U	10-X607	UF Skid 1 Backwash Waste Air Purge Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1U	10-X607	UF Skid 1 Backwash Waste Air Purge Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1V	10-X607	UF Skid 1 Drain Down Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1V	10-X607	UF Skid 1 Drain Down Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1W	10-X607	UF Skid 1 Turbidimeter Sample Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1W	10-X607	UF Skid 1 Turbidimeter Sample Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1X	10-X607	UF Skid 1 Air Scour Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1X	10-X607	UF Skid 1 Air Scour Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-ZH-0203-1Y	10-X607	UF Skid 1 PDT Air Valve Open	LCP-0203-1	ETH	By Vendor	
P25-ZL-0203-1Y	10-X607	UF Skid 1 PDT Air Valve Closed	LCP-0203-1	ETH	By Vendor	
P25-FI-0203-3	10-X607	UF Skid 3 Filtrate Flow	LCP-0203-3	ETH	By Vendor	
P25-XA-0203-3	10-X607	UF Skid 3 General Alarm	LCP-0203-3	ETH	By Vendor	
P25-PDI-0203-3	10-X607	UF Skid 3 Transmembrane Pressure	LCP-0203-3	ETH	By Vendor	
P25-TI-0203-3	10-X607	UF Skid 3 Water Temperature	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3A	10-X607	UF Skid 3 in Production Mode	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3A	10-X607	UF Skid 3 UF Feed Block Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3A	10-X607	UF Skid 3 UF Feed Block Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-AI-0203-3A	10-X607	UF Skid 3 Normalized Permeability	LCP-0203-3	ETH	By Vendor	
P25-PI-0203-3A	10-X607	UF Skid 3 Feed Pressure	LCP-0203-3	ETH	By Vendor	
P25-PI-0203-3B	10-X607	UF Skid 3 Filtrate Pressure	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3B	10-X607	UF Skid 3 UF Feed Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3B	10-X607	UF Skid 3 UF Feed Valve Open	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3B	10-X607	UF Skid 3 in Backwash Mode	LCP-0203-3	ETH	By Vendor	
P25-AI-0203-3B	10-X607	UF Skid 3 Membrane Flux	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3C	10-X607	UF Skid 3 in Maintenance Clean Mode	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3C	10-X607	UF Skid 3 UF Feed Drain Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3C	10-X607	UF Skid 3 UF Feed Drain Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-PI-0203-3C	10-X607	UF Skid 3 Air System Pressure	LCP-0203-3	ETH	By Vendor	
P25-AI-0203-3C	10-X607	UF Skid 3 Filtrate Turbidity	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3D	10-X607	UF Skid 3 CIP Supply Block Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3D	10-X607	UF Skid 3 CIP Supply Block Valve Open	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3D	10-X607	UF Skid 3 in CIP Mode	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3E	10-X607	UF Skid 3 Integrity Test	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3E	10-X607	UF Skid 3 CIP Supply Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3E	10-X607	UF Skid 3 CIP Supply Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3F	10-X607	UF Skid 3 in Standby	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3F	10-X607	UF Skid 3 CIP Supply Drain Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3F	10-X607	UF Skid 3 CIP Supply Drain Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3G	10-X607	UF Skid 3 Backwash Supply Block Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3G	10-X607	UF Skid 3 Backwash Supply Block Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-YI-0203-3G	10-X607	UF Skid 3 Offline	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3H	10-X607	UF Skid 3 Backwash Supply Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3H	10-X607	UF Skid 3 Backwash Supply Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3I	10-X607	UF Skid 3 Backwash Supply Drain Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3I	10-X607	UF Skid 3 Backwash Supply Drain Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3J	10-X607	UF Skid 3 UF Filtrate Block Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3J	10-X607	UF Skid 3 UF Filtrate Block Valve Open	LCP-0203-3	ETH	By Vendor	

P25-ZH-0203-3K	10-X607	UF Skid 3 UF Filtrate Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3K	10-X607	UF Skid 3 UF Filtrate Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3L	10-X607	UF Skid 3 UF Filtrate Drain Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3L	10-X607	UF Skid 3 UF Filtrate Drain Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3M	10-X607	UF Skid 3 UF Filtrate CIP Return Block Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3M	10-X607	UF Skid 3 UF Filtrate CIP Return Block Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3N	10-X607	UF Skid 3 UF Filtrate CIP Return Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3N	10-X607	UF Skid 3 UF Filtrate CIP Return Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3O	10-X607	UF Skid 3 UF Filtrate CIP Return Drain Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3O	10-X607	UF Skid 3 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3P	10-X607	UF Skid 3 Backwash Waste CIP Return Block Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3P	10-X607	UF Skid 3 Backwash Waste CIP Return Block Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3Q	10-X607	UF Skid 3 Backwash Waste CIP Return Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3Q	10-X607	UF Skid 3 Backwash Waste CIP Return Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3R	10-X607	UF Skid 3 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3R	10-X607	UF Skid 3 Backwash Waste CIP Return Drain Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3S	10-X607	UF Skid 3 Backwash Waste Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3S	10-X607	UF Skid 3 Backwash Waste Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3T	10-X607	UF Skid 3 UF Filtrate Air Purge Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3T	10-X607	UF Skid 3 UF Filtrate Air Purge Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3U	10-X607	UF Skid 3 Backwash Waste Air Purge Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3U	10-X607	UF Skid 3 Backwash Waste Air Purge Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3V	10-X607	UF Skid 3 Drain Down Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3V	10-X607	UF Skid 3 Drain Down Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3W	10-X607	UF Skid 3 Turbidimeter Sample Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3W	10-X607	UF Skid 3 Turbidimeter Sample Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3X	10-X607	UF Skid 3 Air Scour Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3X	10-X607	UF Skid 3 Air Scour Valve Open	LCP-0203-3	ETH	By Vendor	
P25-ZL-0203-3Y	10-X607	UF Skid 3 PDT Air Valve Closed	LCP-0203-3	ETH	By Vendor	
P25-ZH-0203-3Y	10-X607	UF Skid 3 PDT Air Valve Open	LCP-0203-3	ETH	By Vendor	
P25-TI-0203-5	10-X607	UF Skid 5 Water Temperature	LCP-0203-5	ETH	By Vendor	
P25-PDI-0203-5	10-X607	UF Skid 5 Transmembrane Pressure	LCP-0203-5	ETH	By Vendor	
P25-FI-0203-5	10-X607	UF Skid 5 Filtrate Flow	LCP-0203-5	ETH	By Vendor	
P25-XA-0203-5	10-X607	UF Skid 5 General Alarm	LCP-0203-5	ETH	By Vendor	
P25-PI-0203-5A	10-X607	UF Skid 5 Feed Pressure	LCP-0203-5	ETH	By Vendor	
P25-YI-0203-5A	10-X607	UF Skid 5 in Production Mode	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5A	10-X607	UF Skid 5 UF Feed Block Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5A	10-X607	UF Skid 5 UF Feed Block Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-AI-0203-5A	10-X607	UF Skid 5 Normalized Permeability	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5B	10-X607	UF Skid 5 UF Feed Valve Open	LCP-0203-5	ETH	By Vendor	
P25-YI-0203-5B	10-X607	UF Skid 5 in Backwash Mode	LCP-0203-5	ETH	By Vendor	
P25-AI-0203-5B	10-X607	UF Skid 5 Membrane Flux	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5B	10-X607	UF Skid 5 UF Feed Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-PI-0203-5B	10-X607	UF Skid 5 Filtrate Pressure	LCP-0203-5	ETH	By Vendor	
P25-YI-0203-5C	10-X607	UF Skid 5 in Maintenance Clean Mode	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5C	10-X607	UF Skid 5 UF Feed Drain Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-PI-0203-5C	10-X607	UF Skid 5 Air System Pressure	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5C	10-X607	UF Skid 5 UF Feed Drain Valve Open	LCP-0203-5	ETH	By Vendor	
P25-AI-0203-5C	10-X607	UF Skid 5 Filtrate Turbidity	LCP-0203-5	ETH	By Vendor	

P25-YI-0203-5D	10-X607	UF Skid 5 in CIP Mode	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5D	10-X607	UF Skid 5 CIP Supply Block Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5D	10-X607	UF Skid 5 CIP Supply Block Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5E	10-X607	UF Skid 5 CIP Supply Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5E	10-X607	UF Skid 5 CIP Supply Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-YI-0203-5E	10-X607	UF Skid 5 Integrity Test	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5F	10-X607	UF Skid 5 CIP Supply Drain Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5F	10-X607	UF Skid 5 CIP Supply Drain Valve Open	LCP-0203-5	ETH	By Vendor	
P25-YI-0203-5F	10-X607	UF Skid 5 in Standby	LCP-0203-5	ETH	By Vendor	
P25-YI-0203-5G	10-X607	UF Skid 5 Offline	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5G	10-X607	UF Skid 5 Backwash Supply Block Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5G	10-X607	UF Skid 5 Backwash Supply Block Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5H	10-X607	UF Skid 5 Backwash Supply Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5H	10-X607	UF Skid 5 Backwash Supply Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5I	10-X607	UF Skid 5 Backwash Supply Drain Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5I	10-X607	UF Skid 5 Backwash Supply Drain Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5J	10-X607	UF Skid 5 UF Filtrate Block Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5J	10-X607	UF Skid 5 UF Filtrate Block Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5K	10-X607	UF Skid 5 UF Filtrate Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5K	10-X607	UF Skid 5 UF Filtrate Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5L	10-X607	UF Skid 5 UF Filtrate Drain Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5L	10-X607	UF Skid 5 UF Filtrate Drain Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5M	10-X607	UF Skid 5 UF Filtrate CIP Return Block Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5M	10-X607	UF Skid 5 UF Filtrate CIP Return Block Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5N	10-X607	UF Skid 5 UF Filtrate CIP Return Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5N	10-X607	UF Skid 5 UF Filtrate CIP Return Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5O	10-X607	UF Skid 5 UF Filtrate CIP Return Drain Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5O	10-X607	UF Skid 5 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5P	10-X607	UF Skid 5 Backwash Waste CIP Return Block Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5P	10-X607	UF Skid 5 Backwash Waste CIP Return Block Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5Q	10-X607	UF Skid 5 Backwash Waste CIP Return Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5Q	10-X607	UF Skid 5 Backwash Waste CIP Return Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5R	10-X607	UF Skid 5 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5R	10-X607	UF Skid 1 Backwash Waste CIP Return Drain Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5S	10-X607	UF Skid 5 Backwash Waste Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5S	10-X607	UF Skid 5 Backwash Waste Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5T	10-X607	UF Skid 5 UF Filtrate Air Purge Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5T	10-X607	UF Skid 5 UF Filtrate Air Purge Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5U	10-X607	UF Skid 5 Backwash Waste Air Purge Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5U	10-X607	UF Skid 5 Backwash Waste Air Purge Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5V	10-X607	UF Skid 5 Drain Down Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5V	10-X607	UF Skid 5 Drain Down Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5W	10-X607	UF Skid 5 Turbidimeter Sample Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5W	10-X607	UF Skid 5 Turbidimeter Sample Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5X	10-X607	UF Skid 5 Air Scour Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5X	10-X607	UF Skid 5 Air Scour Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-ZH-0203-5Y	10-X607	UF Skid 5 PDT Air Valve Open	LCP-0203-5	ETH	By Vendor	
P25-ZL-0203-5Y	10-X607	UF Skid 5 PDT Air Valve Closed	LCP-0203-5	ETH	By Vendor	
P25-XA-0203-11	10-X608	UF Skid 11 General Alarm	LCP-0203-11	ETH	By Vendor	

P25-TI-0203-11	10-X608	UF Skid 11 Water Temperature	LCP-0203-11	ETH	By Vendor	
P25-PDI-0203-11	10-X608	UF Skid 11 Transmembrane Pressure	LCP-0203-11	ETH	By Vendor	
P25-FI-0203-11	10-X608	UF Skid 11 Filtrate Flow	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11A	10-X608	UF Skid 11 UF Feed Block Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11A	10-X608	UF Skid 11 UF Feed Block Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11A	10-X608	UF Skid 11 in Production Mode	LCP-0203-11	ETH	By Vendor	
P25-AI-0203-11A	10-X608	UF Skid 11 Normalized Permeability	LCP-0203-11	ETH	By Vendor	
P25-PI-0203-11A	10-X608	UF Skid 11 Feed Pressure	LCP-0203-11	ETH	By Vendor	
P25-PI-0203-11B	10-X608	UF Skid 11 Filtrate Pressure	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11B	10-X608	UF Skid 11 UF Feed Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11B	10-X608	UF Skid 11 UF Feed Valve Open	LCP-0203-11	ETH	By Vendor	
P25-AI-0203-11B	10-X608	UF Skid 11 Membrane Flux	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11B	10-X608	UF Skid 11 in Backwash Mode	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11C	10-X608	UF Skid 11 in Maintenance Clean Mode	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11C	10-X608	UF Skid 11 UF Feed Drain Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11C	10-X608	UF Skid 11 UF Feed Drain Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-PI-0203-11C	10-X608	UF Skid 11 Air System Pressure	LCP-0203-11	ETH	By Vendor	
P25-AI-0203-11C	10-X608	UF Skid 11 Filtrate Turbidity	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11D	10-X608	UF Skid 11 CIP Supply Block Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11D	10-X608	UF Skid 11 CIP Supply Block Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11D	10-X608	UF Skid 11 in CIP Mode	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11E	10-X608	UF Skid 11 CIP Supply Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11E	10-X608	UF Skid 11 CIP Supply Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11E	10-X608	UF Skid 11 Integrity Test	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11F	10-X608	UF Skid 11 CIP Supply Drain Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11F	10-X608	UF Skid 11 CIP Supply Drain Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11F	10-X608	UF Skid 11 in Standby	LCP-0203-11	ETH	By Vendor	
P25-YI-0203-11G	10-X608	UF Skid 11 Offline	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11G	10-X608	UF Skid 11 Backwash Supply Block Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11G	10-X608	UF Skid 11 Backwash Supply Block Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11H	10-X608	UF Skid 11 Backwash Supply Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11H	10-X608	UF Skid 11 Backwash Supply Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11I	10-X608	UF Skid 11 Backwash Supply Drain Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11I	10-X608	UF Skid 11 Backwash Supply Drain Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11J	10-X608	UF Skid 11 UF Filtrate Block Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11J	10-X608	UF Skid 11 UF Filtrate Block Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11K	10-X608	UF Skid 11 UF Filtrate Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11K	10-X608	UF Skid 11 UF Filtrate Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11L	10-X608	UF Skid 11 UF Filtrate Drain Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11L	10-X608	UF Skid 11 UF Filtrate Drain Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11M	10-X608	UF Skid 11 UF Filtrate CIP Return Block Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11M	10-X608	UF Skid 11 UF Filtrate CIP Return Block Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11N	10-X608	UF Skid 11 UF Filtrate CIP Return Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11N	10-X608	UF Skid 11 UF Filtrate CIP Return Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11O	10-X608	UF Skid 11 UF Filtrate CIP Return Drain Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11O	10-X608	UF Skid 11 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11P	10-X608	UF Skid 11 Backwash Waste CIP Return Block Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11P	10-X608	UF Skid 11 Backwash Waste CIP Return Block Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11Q	10-X608	UF Skid 11 Backwash Waste CIP Return Valve Open	LCP-0203-11	ETH	By Vendor	

P25-ZL-0203-11Q	10-X608	UF Skid 11 Backwash Waste CIP Return Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11R	10-X608	UF Skid 11 Backwash Waste CIP Return Drain Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11R	10-X608	UF Skid 11 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11S	10-X608	UF Skid 11 Backwash Waste Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11S	10-X608	UF Skid 11 Backwash Waste Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11T	10-X608	UF Skid 11 UF Filtrate Air Purge Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11T	10-X608	UF Skid 11 UF Filtrate Air Purge Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11U	10-X608	UF Skid 11 Backwash Waste Air Purge Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11U	10-X608	UF Skid 11 Backwash Waste Air Purge Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11V	10-X608	UF Skid 11 Drain Down Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11V	10-X608	UF Skid 11 Drain Down Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11W	10-X608	UF Skid 11 Turbidimeter Sample Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11W	10-X608	UF Skid 11 Turbidimeter Sample Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11X	10-X608	UF Skid 11 Air Scour Valve Open	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11X	10-X608	UF Skid 11 Air Scour Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZL-0203-11Y	10-X608	UF Skid 11 PDT Air Valve Closed	LCP-0203-11	ETH	By Vendor	
P25-ZH-0203-11Y	10-X608	UF Skid 11 PDT Air Valve Open	LCP-0203-11	ETH	By Vendor	
P25-PDI-0203-7	10-X608	UF Skid 7 Transmembrane Pressure	LCP-0203-7	ETH	By Vendor	
P25-TI-0203-7	10-X608	UF Skid 7 Water Temperature	LCP-0203-7	ETH	By Vendor	
P25-FI-0203-7	10-X608	UF Skid 7 Filtrate Flow	LCP-0203-7	ETH	By Vendor	
P25-XA-0203-7	10-X608	UF Skid 7 General Alarm	LCP-0203-7	ETH	By Vendor	
P25-PI-0203-7A	10-X608	UF Skid 7 Feed Pressure	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7A	10-X608	UF Skid 7 in Production Mode	LCP-0203-7	ETH	By Vendor	
P25-AI-0203-7A	10-X608	UF Skid 7 Normalized Permeability	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7A	10-X608	UF Skid 7 UF Feed Block Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7A	10-X608	UF Skid 7 UF Feed Block Valve Open	LCP-0203-7	ETH	By Vendor	
P25-PI-0203-7B	10-X608	UF Skid 7 Filtrate Pressure	LCP-0203-7	ETH	By Vendor	
P25-AI-0203-7B	10-X608	UF Skid 7 Membrane Flux	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7B	10-X608	UF Skid 7 UF Feed Valve Open	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7B	10-X608	UF Skid 7 in Backwash Mode	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7B	10-X608	UF Skid 7 UF Feed Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7C	10-X608	UF Skid 7 in Maintenance Clean Mode	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7C	10-X608	UF Skid 7 UF Feed Drain Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-AI-0203-7C	10-X608	UF Skid 7 Filtrate Turbidity	LCP-0203-7	ETH	By Vendor	
P25-PI-0203-7C	10-X608	UF Skid 7 Air System Pressure	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7C	10-X608	UF Skid 7 UF Feed Drain Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7D	10-X608	UF Skid 7 CIP Supply Block Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7D	10-X608	UF Skid 7 in CIP Mode	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7D	10-X608	UF Skid 7 CIP Supply Block Valve Open	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7E	10-X608	UF Skid 7 Integrity Test	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7E	10-X608	UF Skid 7 CIP Supply Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7E	10-X608	UF Skid 7 CIP Supply Valve Open	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7F	10-X608	UF Skid 7 in Standby	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7F	10-X608	UF Skid 7 CIP Supply Drain Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7F	10-X608	UF Skid 7 CIP Supply Drain Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7G	10-X608	UF Skid 7 Backwash Supply Block Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7G	10-X608	UF Skid 7 Backwash Supply Block Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-YI-0203-7G	10-X608	UF Skid 7 Offline	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7H	10-X608	UF Skid 7 Backwash Supply Valve Open	LCP-0203-7	ETH	By Vendor	

P25-ZL-0203-7H	10-X608	UF Skid 7 Backwash Supply Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7I	10-X608	UF Skid 7 Backwash Supply Drain Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7I	10-X608	UF Skid 7 Backwash Supply Drain Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7J	10-X608	UF Skid 7 UF Filtrate Block Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7J	10-X608	UF Skid 7 UF Filtrate Block Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7K	10-X608	UF Skid 7 UF Filtrate Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7K	10-X608	UF Skid 7 UF Filtrate Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7L	10-X608	UF Skid 7 UF Filtrate Drain Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7L	10-X608	UF Skid 7 UF Filtrate Drain Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7M	10-X608	UF Skid 7 UF Filtrate CIP Return Block Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7M	10-X608	UF Skid 7 UF Filtrate CIP Return Block Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7N	10-X608	UF Skid 7 UF Filtrate CIP Return Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7N	10-X608	UF Skid 7 UF Filtrate CIP Return Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7O	10-X608	UF Skid 7 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7O	10-X608	UF Skid 7 UF Filtrate CIP Return Drain Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7P	10-X608	UF Skid 7 Backwash Waste CIP Return Block Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7P	10-X608	UF Skid 7 Backwash Waste CIP Return Block Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7Q	10-X608	UF Skid 7 Backwash Waste CIP Return Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7Q	10-X608	UF Skid 7 Backwash Waste CIP Return Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7R	10-X608	UF Skid 7 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7R	10-X608	UF Skid 7 Backwash Waste CIP Return Drain Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7S	10-X608	UF Skid 7 Backwash Waste Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7S	10-X608	UF Skid 7 Backwash Waste Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7T	10-X608	UF Skid 7 UF Filtrate Air Purge Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7T	10-X608	UF Skid 7 UF Filtrate Air Purge Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7U	10-X608	UF Skid 7 Backwash Waste Air Purge Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7U	10-X608	UF Skid 7 Backwash Waste Air Purge Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7V	10-X608	UF Skid 7 Drain Down Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7V	10-X608	UF Skid 7 Drain Down Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7W	10-X608	UF Skid 7 Turbidimeter Sample Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7W	10-X608	UF Skid 7 Turbidimeter Sample Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7X	10-X608	UF Skid 7 Air Scour Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7X	10-X608	UF Skid 7 Air Scour Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-ZH-0203-7Y	10-X608	UF Skid 7 PDT Air Valve Open	LCP-0203-7	ETH	By Vendor	
P25-ZL-0203-7Y	10-X608	UF Skid 7 PDT Air Valve Closed	LCP-0203-7	ETH	By Vendor	
P25-PDI-0203-9	10-X608	UF Skid 9 Transmembrane Pressure	LCP-0203-9	ETH	By Vendor	
P25-TI-0203-9	10-X608	UF Skid 9 Water Temperature	LCP-0203-9	ETH	By Vendor	
P25-XA-0203-9	10-X608	UF Skid 9 General Alarm	LCP-0203-9	ETH	By Vendor	
P25-FI-0203-9	10-X608	UF Skid 9 Filtrate Flow	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9A	10-X608	UF Skid 9 in Production Mode	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9A	10-X608	UF Skid 9 UF Feed Block Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9A	10-X608	UF Skid 9 UF Feed Block Valve Open	LCP-0203-9	ETH	By Vendor	
P25-AI-0203-9A	10-X608	UF Skid 9 Normalized Permeability	LCP-0203-9	ETH	By Vendor	
P25-PI-0203-9A	10-X608	UF Skid 9 Feed Pressure	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9B	10-X608	UF Skid 9 UF Feed Valve Open	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9B	10-X608	UF Skid 9 in Backwash Mode	LCP-0203-9	ETH	By Vendor	
P25-AI-0203-9B	10-X608	UF Skid 9 Membrane Flux	LCP-0203-9	ETH	By Vendor	
P25-PI-0203-9B	10-X608	UF Skid 9 Filtrate Pressure	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9B	10-X608	UF Skid 9 UF Feed Valve Closed	LCP-0203-9	ETH	By Vendor	

P25-ZH-0203-9C	10-X608	UF Skid 9 UF Feed Drain Valve Open	LCP-0203-9	ETH	By Vendor	
P25-PI-0203-9C	10-X608	UF Skid 9 Air System Pressure	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9C	10-X608	UF Skid 9 UF Feed Drain Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-AI-0203-9C	10-X608	UF Skid 9 Filtrate Turbidity	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9C	10-X608	UF Skid 9 in Maintenance Clean Mode	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9D	10-X608	UF Skid 9 in CIP Mode	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9D	10-X608	UF Skid 9 CIP Supply Block Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9D	10-X608	UF Skid 9 CIP Supply Block Valve Open	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9E	10-X608	UF Skid 9 Integrity Test	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9E	10-X608	UF Skid 9 CIP Supply Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9E	10-X608	UF Skid 9 CIP Supply Valve Open	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9F	10-X608	UF Skid 9 in Standby	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9F	10-X608	UF Skid 9 CIP Supply Drain Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9F	10-X608	UF Skid 9 CIP Supply Drain Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9G	10-X608	UF Skid 9 Backwash Supply Block Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9G	10-X608	UF Skid 9 Backwash Supply Block Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-YI-0203-9G	10-X608	UF Skid 9 Offline	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9H	10-X608	UF Skid 9 Backwash Supply Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9H	10-X608	UF Skid 9 Backwash Supply Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9I	10-X608	UF Skid 9 Backwash Supply Drain Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9I	10-X608	UF Skid 9 Backwash Supply Drain Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9J	10-X608	UF Skid 9 UF Filtrate Block Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9J	10-X608	UF Skid 9 UF Filtrate Block Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9K	10-X608	UF Skid 9 UF Filtrate Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9K	10-X608	UF Skid 9 UF Filtrate Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9L	10-X608	UF Skid 9 UF Filtrate Drain Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9L	10-X608	UF Skid 9 UF Filtrate Drain Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9M	10-X608	UF Skid 9 UF Filtrate CIP Return Block Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9M	10-X608	UF Skid 9 UF Filtrate CIP Return Block Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9N	10-X608	UF Skid 9 UF Filtrate CIP Return Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9N	10-X608	UF Skid 9 UF Filtrate CIP Return Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9O	10-X608	UF Skid 9 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9O	10-X608	UF Skid 9 UF Filtrate CIP Return Drain Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9P	10-X608	UF Skid 9 Backwash Waste CIP Return Block Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9P	10-X608	UF Skid 9 Backwash Waste CIP Return Block Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9Q	10-X608	UF Skid 9 Backwash Waste CIP Return Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9Q	10-X608	UF Skid 9 Backwash Waste CIP Return Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9R	10-X608	UF Skid 9 Backwash Waste CIP Return Drain Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9R	10-X608	UF Skid 9 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9S	10-X608	UF Skid 9 Backwash Waste Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9S	10-X608	UF Skid 9 Backwash Waste Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9T	10-X608	UF Skid 9 UF Filtrate Air Purge Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9T	10-X608	UF Skid 9 UF Filtrate Air Purge Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9U	10-X608	UF Skid 9 Backwash Waste Air Purge Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9U	10-X608	UF Skid 9 Backwash Waste Air Purge Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9V	10-X608	UF Skid 9 Drain Down Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9V	10-X608	UF Skid 9 Drain Down Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9W	10-X608	UF Skid 9 Turbidimeter Sample Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9W	10-X608	UF Skid 9 Turbidimeter Sample Valve Open	LCP-0203-9	ETH	By Vendor	

P25-ZL-0203-9X	10-X608	UF Skid 9 Air Scour Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9X	10-X608	UF Skid 9 Air Scour Valve Open	LCP-0203-9	ETH	By Vendor	
P25-ZL-0203-9Y	10-X608	UF Skid 9 PDT Air Valve Closed	LCP-0203-9	ETH	By Vendor	
P25-ZH-0203-9Y	10-X608	UF Skid 9 PDT Air Valve Open	LCP-0203-9	ETH	By Vendor	
P25-PDI-0203-13	10-X609	UF Skid 13 Transmembrane Pressure	LCP-0203-13	ETH	By Vendor	
P25-XA-0203-13	10-X609	UF Skid 13 General Alarm	LCP-0203-13	ETH	By Vendor	
P25-FI-0203-13	10-X609	UF Skid 13 Filtrate Flow	LCP-0203-13	ETH	By Vendor	
P25-TI-0203-13	10-X609	UF Skid 13 Water Temperature	LCP-0203-13	ETH	By Vendor	
P25-PI-0203-13A	10-X609	UF Skid 13 Feed Pressure	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13A	10-X609	UF Skid 13 UF Feed Block Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13A	10-X609	UF Skid 13 UF Feed Block Valve Open	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13A	10-X609	UF Skid 13 in Production Mode	LCP-0203-13	ETH	By Vendor	
P25-AI-0203-13A	10-X609	UF Skid 13 Normalized Permeability	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13B	10-X609	UF Skid 13 UF Feed Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-AI-0203-13B	10-X609	UF Skid 13 Membrane Flux	LCP-0203-13	ETH	By Vendor	
P25-PI-0203-13B	10-X609	UF Skid 13 Filtrate Pressure	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13B	10-X609	UF Skid 13 in Backwash Mode	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13B	10-X609	UF Skid 13 UF Feed Valve Open	LCP-0203-13	ETH	By Vendor	
P25-PI-0203-13C	10-X609	UF Skid 13 Air System Pressure	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13C	10-X609	UF Skid 13 in Maintenance Clean Mode	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13C	10-X609	UF Skid 13 UF Feed Drain Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-AI-0203-13C	10-X609	UF Skid 13 Filtrate Turbidity	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13C	10-X609	UF Skid 13 UF Feed Drain Valve Open	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13D	10-X609	UF Skid 13 in CIP Mode	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13D	10-X609	UF Skid 13 CIP Supply Block Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13D	10-X609	UF Skid 13 CIP Supply Block Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13E	10-X609	UF Skid 13 CIP Supply Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13E	10-X609	UF Skid 13 CIP Supply Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13E	10-X609	UF Skid 13 Integrity Test	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13F	10-X609	UF Skid 13 CIP Supply Drain Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13F	10-X609	UF Skid 13 in Standby	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13F	10-X609	UF Skid 13 CIP Supply Drain Valve Open	LCP-0203-13	ETH	By Vendor	
P25-YI-0203-13G	10-X609	UF Skid 13 Offline	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13G	10-X609	UF Skid 13 Backwash Supply Block Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13G	10-X609	UF Skid 13 Backwash Supply Block Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13H	10-X609	UF Skid 13 Backwash Supply Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13H	10-X609	UF Skid 13 Backwash Supply Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13I	10-X609	UF Skid 13 Backwash Supply Drain Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13I	10-X609	UF Skid 13 Backwash Supply Drain Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13J	10-X609	UF Skid 13 UF Filtrate Block Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13J	10-X609	UF Skid 13 UF Filtrate Block Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13K	10-X609	UF Skid 13 UF Filtrate Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13K	10-X609	UF Skid 13 UF Filtrate Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13L	10-X609	UF Skid 13 UF Filtrate Drain Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13L	10-X609	UF Skid 13 UF Filtrate Drain Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13M	10-X609	UF Skid 13 UF Filtrate CIP Return Block Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13M	10-X609	UF Skid 13 UF Filtrate CIP Return Block Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13N	10-X609	UF Skid 13 UF Filtrate CIP Return Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13N	10-X609	UF Skid 13 UF Filtrate CIP Return Valve Closed	LCP-0203-13	ETH	By Vendor	

P25-ZH-0203-13O	10-X609	UF Skid 13 UF Filtrate CIP Return Drain Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13O	10-X609	UF Skid 13 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13P	10-X609	UF Skid 13 Backwash Waste CIP Return Block Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13P	10-X609	UF Skid 13 Backwash Waste CIP Return Block Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13Q	10-X609	UF Skid 13 Backwash Waste CIP Return Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13Q	10-X609	UF Skid 13 Backwash Waste CIP Return Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13R	10-X609	UF Skid 13 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13R	10-X609	UF Skid 13 Backwash Waste CIP Return Drain Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13S	10-X609	UF Skid 13 Backwash Waste Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13S	10-X609	UF Skid 13 Backwash Waste Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13T	10-X609	UF Skid 13 UF Filtrate Air Purge Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13T	10-X609	UF Skid 13 UF Filtrate Air Purge Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13U	10-X609	UF Skid 13 Backwash Waste Air Purge Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13U	10-X609	UF Skid 13 Backwash Waste Air Purge Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13V	10-X609	UF Skid 13 Drain Down Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13V	10-X609	UF Skid 13 Drain Down Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13W	10-X609	UF Skid 13 Turbidimeter Sample Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13W	10-X609	UF Skid 13 Turbidimeter Sample Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13X	10-X609	UF Skid 13 Air Scour Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13X	10-X609	UF Skid 13 Air Scour Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZH-0203-13Y	10-X609	UF Skid 13 PDT Air Valve Open	LCP-0203-13	ETH	By Vendor	
P25-ZL-0203-13Y	10-X609	UF Skid 13 PDT Air Valve Closed	LCP-0203-13	ETH	By Vendor	
P25-FI-0203-2	10-X610	UF Skid 2 Filtrate Flow	LCP-0203-2	ETH	By Vendor	
P25-PDI-0203-2	10-X610	UF Skid 2 Transmembrane Pressure	LCP-0203-2	ETH	By Vendor	
P25-TI-0203-2	10-X610	UF Skid 2 Water Temperature	LCP-0203-2	ETH	By Vendor	
P25-XA-0203-2	10-X610	UF Skid 2 General Alarm	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2A	10-X610	UF Skid 2 UF Feed Block Valve Open	LCP-0203-2	ETH	By Vendor	
P25-AI-0203-2A	10-X610	UF Skid 2 Normalized Permeability	LCP-0203-2	ETH	By Vendor	
P25-PI-0203-2A?	10-X610	UF Skid 2 Feed Pressure	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2A	10-X610	UF Skid 2 UF Feed Block Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2A	10-X610	UF Skid 2 in Production Mode	LCP-0203-2	ETH	By Vendor	
P25-PI-0203-2B?	10-X610	UF Skid 2 Filtrate Pressure	LCP-0203-2	ETH	By Vendor	
P25-AI-0203-2B	10-X610	UF Skid 2 Membrane Flux	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2B	10-X610	UF Skid 2 UF Feed Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2B	10-X610	UF Skid 2 UF Feed Valve Open	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2B	10-X610	UF Skid 2 in Backwash Mode	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2C	10-X610	UF Skid 2 UF Feed Drain Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2C	10-X610	UF Skid 2 in Maintenance Clean Mode	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2C	10-X610	UF Skid 2 UF Feed Drain Valve Open	LCP-0203-2	ETH	By Vendor	
P25-PI-0203-2C	10-X610	UF Skid 2 Air System Pressure	LCP-0203-2	ETH	By Vendor	
P25-AI-0203-2C	10-X610	UF Skid 2 Membrane Flux	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2D	10-X610	UF Skid 2 CIP Supply Block Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2D	10-X610	UF Skid 2 in CIP Mode	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2D	10-X610	UF Skid 2 CIP Supply Block Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2E	10-X610	UF Skid 2 CIP Supply Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2E	10-X610	UF Skid 2 Integrity Test	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2E	10-X610	UF Skid 2 CIP Supply Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2F	10-X610	UF Skid 2 CIP Supply Drain Valve Open	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2F	10-X610	UF Skid 2 in Standby	LCP-0203-2	ETH	By Vendor	

P25-ZL-0203-2F	10-X610	UF Skid 2 CIP Supply Drain Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2G	10-X610	UF Skid 2 Backwash Supply Block Valve Open	LCP-0203-2	ETH	By Vendor	
P25-YI-0203-2G	10-X610	UF Skid 2 Offline	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2G	10-X610	UF Skid 2 Backwash Supply Block Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2H	10-X610	UF Skid 2 Backwash Supply Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2H	10-X610	UF Skid 2 Backwash Supply Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2I	10-X610	UF Skid 2 Backwash Supply Drain Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2I	10-X610	UF Skid 2 Backwash Supply Drain Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2J	10-X610	UF Skid 2 UF Filtrate Block Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2J	10-X610	UF Skid 2 UF Filtrate Block Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2K	10-X610	UF Skid 2 UF Filtrate Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2K	10-X610	UF Skid 2 UF Filtrate Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2L	10-X610	UF Skid 2 UF Filtrate Drain Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2L	10-X610	UF Skid 2 UF Filtrate Drain Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2M	10-X610	UF Skid 2 UF Filtrate CIP Return Block Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2M	10-X610	UF Skid 2 UF Filtrate CIP Return Block Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2N	10-X610	UF Skid 2 UF Filtrate CIP Return Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2N	10-X610	UF Skid 2 UF Filtrate CIP Return Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2O	10-X610	UF Skid 2 UF Filtrate CIP Return Drain Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2O	10-X610	UF Skid 2 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2P	10-X610	UF Skid 2 Backwash Waste CIP Return Block Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2P	10-X610	UF Skid 2 Backwash Waste CIP Return Block Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2Q	10-X610	UF Skid 2 Backwash Waste CIP Return Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2Q	10-X610	UF Skid 2 Backwash Waste CIP Return Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2R	10-X610	UF Skid 2 Backwash Waste CIP Return Drain Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2R	10-X610	UF Skid 2 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2S	10-X610	UF Skid 2 Backwash Waste Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2S	10-X610	UF Skid 2 Backwash Waste Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2T	10-X610	UF Skid 2 UF Filtrate Air Purge Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2T	10-X610	UF Skid 2 UF Filtrate Air Purge Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2U	10-X610	UF Skid 2 Backwash Waste Air Purge Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2U	10-X610	UF Skid 2 Backwash Waste Air Purge Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2V	10-X610	UF Skid 2 Drain Down Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2V	10-X610	UF Skid 2 Drain Down Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2W	10-X610	UF Skid 2 Turbidimeter Sample Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2W	10-X610	UF Skid 2 Turbidimeter Sample Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2X	10-X610	UF Skid 2 Air Scour Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2X	10-X610	UF Skid 2 Air Scour Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-ZH-0203-2Y	10-X610	UF Skid 2 PDT Air Valve Open	LCP-0203-2	ETH	By Vendor	
P25-ZL-0203-2Y	10-X610	UF Skid 2 PDT Air Valve Closed	LCP-0203-2	ETH	By Vendor	
P25-FI-0203-4	10-X610	UF Skid 4 Filtrate Flow	LCP-0203-4	ETH	By Vendor	
P25-TI-0203-4	10-X610	UF Skid 4 Water Temperature	LCP-0203-4	ETH	By Vendor	
P25-PDI-0203-4	10-X610	UF Skid 4 Transmembrane Pressure	LCP-0203-4	ETH	By Vendor	
P25-XA-0203-4	10-X610	UF Skid 4 General Alarm	LCP-0203-4	ETH	By Vendor	
P25-AI-0203-4A	10-X610	UF Skid 4 Normalized Permeability	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4A	10-X610	UF Skid 4 in Production Mode	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4A	10-X610	UF Skid 4 UF Feed Block Valve Open	LCP-0203-4	ETH	By Vendor	
P25-PI-0203-4A	10-X610	UF Skid 4 Feed Pressure	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4A	10-X610	UF Skid 4 UF Feed Block Valve Closed	LCP-0203-4	ETH	By Vendor	

P25-PI-0203-4B	10-X610	UF Skid 4 Filtrate Pressure	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4B	10-X610	UF Skid 4 UF Feed Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4B	10-X610	UF Skid 4 UF Feed Valve Open	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4B	10-X610	UF Skid 4 in Backwash Mode	LCP-0203-4	ETH	By Vendor	
P25-AI-0203-4B	10-X610	UF Skid 4 Membrane Flux	LCP-0203-4	ETH	By Vendor	
P25-AI-0203-4C	10-X610	UF Skid 4 Membrane Flux	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4C	10-X610	UF Skid 4 in Maintenance Clean Mode	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4C	10-X610	UF Skid 4 UF Feed Drain Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4C	10-X610	UF Skid 4 UF Feed Drain Valve Open	LCP-0203-4	ETH	By Vendor	
P25-PI-0203-4C	10-X610	UF Skid 4 Air System Pressure	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4D	10-X610	UF Skid 4 CIP Supply Block Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4D	10-X610	UF Skid 4 in CIP Mode	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4D	10-X610	UF Skid 4 CIP Supply Block Valve Open	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4E	10-X610	UF Skid 4 Integrity Test	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4E	10-X610	UF Skid 4 CIP Supply Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4E	10-X610	UF Skid 4 CIP Supply Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4F	10-X610	UF Skid 4 CIP Supply Drain Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4F	10-X610	UF Skid 4 in Standby	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4F	10-X610	UF Skid 4 CIP Supply Drain Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4G	10-X610	UF Skid 4 Backwash Supply Block Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-YI-0203-4G	10-X610	UF Skid 4 Offline	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4G	10-X610	UF Skid 4 Backwash Supply Block Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4H	10-X610	UF Skid 4 Backwash Supply Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4H	10-X610	UF Skid 4 Backwash Supply Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4I	10-X610	UF Skid 4 Backwash Supply Drain Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4I	10-X610	UF Skid 4 Backwash Supply Drain Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4J	10-X610	UF Skid 4 UF Filtrate Block Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4J	10-X610	UF Skid 4 UF Filtrate Block Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4K	10-X610	UF Skid 4 UF Filtrate Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4K	10-X610	UF Skid 4 UF Filtrate Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4L	10-X610	UF Skid 4 UF Filtrate Drain Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4L	10-X610	UF Skid 4 UF Filtrate Drain Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4M	10-X610	UF Skid 4 UF Filtrate CIP Return Block Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4M	10-X610	UF Skid 4 UF Filtrate CIP Return Block Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4N	10-X610	UF Skid 4 UF Filtrate CIP Return Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4N	10-X610	UF Skid 4 UF Filtrate CIP Return Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4O	10-X610	UF Skid 4 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4O	10-X610	UF Skid 4 UF Filtrate CIP Return Drain Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4P	10-X610	UF Skid 4 Backwash Waste CIP Return Block Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4P	10-X610	UF Skid 4 Backwash Waste CIP Return Block Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4Q	10-X610	UF Skid 4 Backwash Waste CIP Return Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4Q	10-X610	UF Skid 4 Backwash Waste CIP Return Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4R	10-X610	UF Skid 4 Backwash Waste CIP Return Drain Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4R	10-X610	UF Skid 4 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4S	10-X610	UF Skid 4 Backwash Waste Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4S	10-X610	UF Skid 4 Backwash Waste Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4T	10-X610	UF Skid 4 UF Filtrate Air Purge Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4T	10-X610	UF Skid 4 UF Filtrate Air Purge Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4U	10-X610	UF Skid 4 Backwash Waste Air Purge Valve Open	LCP-0203-4	ETH	By Vendor	

P25-ZL-0203-4U	10-X610	UF Skid 4 Backwash Waste Air Purge Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4V	10-X610	UF Skid 4 Drain Down Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4V	10-X610	UF Skid 4 Drain Down Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4W	10-X610	UF Skid 4 Turbidimeter Sample Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4W	10-X610	UF Skid 4 Turbidimeter Sample Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4X	10-X610	UF Skid 4 Air Scour Valve Open	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4X	10-X610	UF Skid 4 Air Scour Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZL-0203-4Y	10-X610	UF Skid 4 PDT Air Valve Closed	LCP-0203-4	ETH	By Vendor	
P25-ZH-0203-4Y	10-X610	UF Skid 4 PDT Air Valve Open	LCP-0203-4	ETH	By Vendor	
P25-TI-0203-6	10-X610	UF Skid 6 Water Temperature	LCP-0203-6	ETH	By Vendor	
P25-XA-0203-6	10-X610	UF Skid 6 General Alarm	LCP-0203-6	ETH	By Vendor	
P25-PDI-0203-6	10-X610	UF Skid 6 Transmembrane Pressure	LCP-0203-6	ETH	By Vendor	
P25-FI-0203-6	10-X610	UF Skid 6 Filtrate Flow	LCP-0203-6	ETH	By Vendor	
P25-AI-0203-6A	10-X610	UF Skid 6 Normalized Permeability	LCP-0203-6	ETH	By Vendor	
P25-PI-0203-6A	10-X610	UF Skid 6 Feed Pressure	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6A	10-X610	UF Skid 6 in Production Mode	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6A	10-X610	UF Skid 6 UF Feed Block Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6A	10-X610	UF Skid 6 UF Feed Block Valve Open	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6B	10-X610	UF Skid 6 in Backwash Mode	LCP-0203-6	ETH	By Vendor	
P25-AI-0203-6B	10-X610	UF Skid 6 Membrane Flux	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6B	10-X610	UF Skid 6 UF Feed Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-PI-0203-6B	10-X610	UF Skid 6 Filtrate Pressure	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6B	10-X610	UF Skid 6 UF Feed Valve Open	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6C	10-X610	UF Skid 6 in Maintenance Clean Mode	LCP-0203-6	ETH	By Vendor	
P25-PI-0203-6C	10-X610	UF Skid 6 Air System Pressure	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6C	10-X610	UF Skid 6 UF Feed Drain Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6C	10-X610	UF Skid 6 UF Feed Drain Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-AI-0203-6C	10-X610	UF Skid 6 Filtrate Turbidity	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6D	10-X610	UF Skid 6 CIP Supply Block Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6D	10-X610	UF Skid 6 CIP Supply Block Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6D	10-X610	UF Skid 6 in CIP Mode	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6E	10-X610	UF Skid 6 Integrity Test	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6E	10-X610	UF Skid 6 CIP Supply Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6E	10-X610	UF Skid 6 CIP Supply Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6F	10-X610	UF Skid 6 in Standby	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6F	10-X610	UF Skid 6 CIP Supply Drain Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6F	10-X610	UF Skid 6 CIP Supply Drain Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6G	10-X610	UF Skid 6 Backwash Supply Block Valve Open	LCP-0203-6	ETH	By Vendor	
P25-YI-0203-6G	10-X610	UF Skid 6 Offline	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6G	10-X610	UF Skid 6 Backwash Supply Block Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6H	10-X610	UF Skid 6 Backwash Supply Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6H	10-X610	UF Skid 6 Backwash Supply Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6I	10-X610	UF Skid 6 Backwash Supply Drain Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6I	10-X610	UF Skid 6 Backwash Supply Drain Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6J	10-X610	UF Skid 6 UF Filtrate Block Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6J	10-X610	UF Skid 6 UF Filtrate Block Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6K	10-X610	UF Skid 6 UF Filtrate Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6K	10-X610	UF Skid 6 UF Filtrate Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6L	10-X610	UF Skid 6 UF Filtrate Drain Valve Closed	LCP-0203-6	ETH	By Vendor	

P25-ZH-0203-6L	10-X610	UF Skid 6 UF Filtrate Drain Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6M	10-X610	UF Skid 6 UF Filtrate CIP Return Block Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6M	10-X610	UF Skid 6 UF Filtrate CIP Return Block Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6N	10-X610	UF Skid 6 UF Filtrate CIP Return Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6N	10-X610	UF Skid 6 UF Filtrate CIP Return Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6O	10-X610	UF Skid 6 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6O	10-X610	UF Skid 6 UF Filtrate CIP Return Drain Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6P	10-X610	UF Skid 6 Backwash Waste CIP Return Block Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6P	10-X610	UF Skid 6 Backwash Waste CIP Return Block Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6Q	10-X610	UF Skid 6 Backwash Waste CIP Return Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6Q	10-X610	UF Skid 6 Backwash Waste CIP Return Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6R	10-X610	UF Skid 6 Backwash Waste CIP Return Drain Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6R	10-X610	UF Skid 6 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6S	10-X610	UF Skid 6 Backwash Waste Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6S	10-X610	UF Skid 6 Backwash Waste Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6T	10-X610	UF Skid 6 UF Filtrate Air Purge Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6T	10-X610	UF Skid 6 UF Filtrate Air Purge Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6U	10-X610	UF Skid 6 Backwash Waste Air Purge Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6U	10-X610	UF Skid 6 Backwash Waste Air Purge Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6V	10-X610	UF Skid 6 Drain Down Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6V	10-X610	UF Skid 6 Drain Down Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6W	10-X610	UF Skid 6 Turbidimeter Sample Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6W	10-X610	UF Skid 6 Turbidimeter Sample Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6X	10-X610	UF Skid 6 Air Scour Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6X	10-X610	UF Skid 6 Air Scour Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZH-0203-6Y	10-X610	UF Skid 6 PDT Air Valve Open	LCP-0203-6	ETH	By Vendor	
P25-ZL-0203-6Y	10-X610	UF Skid 6 PDT Air Valve Closed	LCP-0203-6	ETH	By Vendor	
P25-PDI-0203-10	10-X611	UF Skid 10 Transmembrane Pressure	LCP-0203-10	ETH	By Vendor	
P25-XA-0203-10	10-X611	UF Skid 10 General Alarm	LCP-0203-10	ETH	By Vendor	
P25-FI-0203-10	10-X611	UF Skid 10 Filtrate Flow	LCP-0203-10	ETH	By Vendor	
P25-TI-0203-10	10-X611	UF Skid 10 Water Temperature	LCP-0203-10	ETH	By Vendor	
P25-AI-0203-10A	10-X611	UF Skid 10 Normalized Permeability	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10A	10-X611	UF Skid 10 UF Feed Block Valve Open	LCP-0203-10	ETH	By Vendor	
P25-PI-0203-10A	10-X611	UF Skid 10 Feed Pressure	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10A	10-X611	UF Skid 10 UF Feed Block Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10A	10-X611	UF Skid 10 in Production Mode	LCP-0203-10	ETH	By Vendor	
P25-PI-0203-10B	10-X611	UF Skid 10 Filtrate Pressure	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10B	10-X611	UF Skid 10 UF Feed Valve Open	LCP-0203-10	ETH	By Vendor	
P25-AI-0203-10B	10-X611	UF Skid 10 Membrane Flux	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10B	10-X611	UF Skid 10 in Backwash Mode	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10B	10-X611	UF Skid 10 UF Feed Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10C	10-X611	UF Skid 10 UF Feed Drain Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-PI-0203-10C	10-X611	UF Skid 10 Air System Pressure	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10C	10-X611	UF Skid 10 in Maintenance Clean Mode	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10C	10-X611	UF Skid 10 UF Feed Drain Valve Open	LCP-0203-10	ETH	By Vendor	
P25-AI-0203-10C	10-X611	UF Skid 10 Filtrate Turbidity	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10D	10-X611	UF Skid 10 in CIP Mode	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10D	10-X611	UF Skid 10 CIP Supply Block Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10D	10-X611	UF Skid 10 CIP Supply Block Valve Open	LCP-0203-10	ETH	By Vendor	

P25-ZH-0203-10E	10-X611	UF Skid 10 CIP Supply Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10E	10-X611	UF Skid 10 CIP Supply Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10E	10-X611	UF Skid 10 Integrity Test	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10F	10-X611	UF Skid 10 CIP Supply Drain Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10F	10-X611	UF Skid 10 CIP Supply Drain Valve Open	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10F	10-X611	UF Skid 10 in Standby	LCP-0203-10	ETH	By Vendor	
P25-YI-0203-10G	10-X611	UF Skid 10 Offline	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10G	10-X611	UF Skid 10 Backwash Supply Block Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10G	10-X611	UF Skid 10 Backwash Supply Block Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10H	10-X611	UF Skid 10 Backwash Supply Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10H	10-X611	UF Skid 10 Backwash Supply Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10I	10-X611	UF Skid 10 Backwash Supply Drain Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10I	10-X611	UF Skid 10 Backwash Supply Drain Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10J	10-X611	UF Skid 10 UF Filtrate Block Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10J	10-X611	UF Skid 10 UF Filtrate Block Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10K	10-X611	UF Skid 10 UF Filtrate Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10K	10-X611	UF Skid 10 UF Filtrate Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10L	10-X611	UF Skid 10 UF Filtrate Drain Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10L	10-X611	UF Skid 10 UF Filtrate Drain Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10M	10-X611	UF Skid 10 UF Filtrate CIP Return Block Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10M	10-X611	UF Skid 10 UF Filtrate CIP Return Block Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10N	10-X611	UF Skid 10 UF Filtrate CIP Return Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10N	10-X611	UF Skid 10 UF Filtrate CIP Return Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10O	10-X611	UF Skid 10 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10O	10-X611	UF Skid 10 UF Filtrate CIP Return Drain Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10P	10-X611	UF Skid 10 Backwash Waste CIP Return Block Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10P	10-X611	UF Skid 10 Backwash Waste CIP Return Block Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10Q	10-X611	UF Skid 10 Backwash Waste CIP Return Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10Q	10-X611	UF Skid 10 Backwash Waste CIP Return Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10R	10-X611	UF Skid 10 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10R	10-X611	UF Skid 10 Backwash Waste CIP Return Drain Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10S	10-X611	UF Skid 10 Backwash Waste Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10S	10-X611	UF Skid 10 Backwash Waste Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10T	10-X611	UF Skid 10 UF Filtrate Air Purge Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10T	10-X611	UF Skid 10 UF Filtrate Air Purge Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10U	10-X611	UF Skid 10 Backwash Waste Air Purge Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10U	10-X611	UF Skid 10 Backwash Waste Air Purge Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10V	10-X611	UF Skid 10 Drain Down Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10V	10-X611	UF Skid 10 Drain Down Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10W	10-X611	UF Skid 10 Turbidimeter Sample Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10W	10-X611	UF Skid 10 Turbidimeter Sample Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10X	10-X611	UF Skid 10 Air Scour Valve Open	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10X	10-X611	UF Skid 10 Air Scour Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZL-0203-10Y	10-X611	UF Skid 10 PDT Air Valve Closed	LCP-0203-10	ETH	By Vendor	
P25-ZH-0203-10Y	10-X611	UF Skid 10 PDT Air Valve Open	LCP-0203-10	ETH	By Vendor	
P25-TI-0203-12	10-X611	UF Skid 12 Water Temperature	LCP-0203-12	ETH	By Vendor	
P25-FI-0203-12	10-X611	UF Skid 12 Filtrate Flow	LCP-0203-12	ETH	By Vendor	
P25-XA-0203-12	10-X611	UF Skid 12 General Alarm	LCP-0203-12	ETH	By Vendor	
P25-PDI-0203-12	10-X611	UF Skid 12 Transmembrane Pressure	LCP-0203-12	ETH	By Vendor	

P25-ZL-0203-12A	10-X611	UF Skid 12 UF Feed Block Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-AI-0203-12A	10-X611	UF Skid 12 Normalized Permeability	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12A	10-X611	UF Skid 12 UF Feed Block Valve Open	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12A	10-X611	UF Skid 12 in Production Mode	LCP-0203-12	ETH	By Vendor	
P25-PI-0203-12A	10-X611	UF Skid 12 Feed Pressure	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12B	10-X611	UF Skid 12 in Backwash Mode	LCP-0203-12	ETH	By Vendor	
P25-AI-0203-12B	10-X611	UF Skid 12 Membrane Flux	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12B	10-X611	UF Skid 12 UF Feed Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12B	10-X611	UF Skid 12 UF Feed Valve Open	LCP-0203-12	ETH	By Vendor	
P25-PI-0203-12B	10-X611	UF Skid 12 Filtrate Pressure	LCP-0203-12	ETH	By Vendor	
P25-AI-0203-12C	10-X611	UF Skid 12 Filtrate Turbidity	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12C	10-X611	UF Skid 12 in Maintenance Clean Mode	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12C	10-X611	UF Skid 12 UF Feed Drain Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-PI-0203-12C	10-X611	UF Skid 12 Air System Pressure	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12C	10-X611	UF Skid 12 UF Feed Drain Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12D	10-X611	UF Skid 12 CIP Supply Block Valve Open	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12D	10-X611	UF Skid 12 in CIP Mode	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12D	10-X611	UF Skid 12 CIP Supply Block Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12E	10-X611	UF Skid 12 CIP Supply Valve Open	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12E	10-X611	UF Skid 12 Integrity Test	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12E	10-X611	UF Skid 12 CIP Supply Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12F	10-X611	UF Skid 12 CIP Supply Drain Valve Open	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12F	10-X611	UF Skid 12 in Standby	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12F	10-X611	UF Skid 12 CIP Supply Drain Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12G	10-X611	UF Skid 12 Backwash Supply Block Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12G	10-X611	UF Skid 12 Backwash Supply Block Valve Open	LCP-0203-12	ETH	By Vendor	
P25-YI-0203-12G	10-X611	UF Skid 12 Offline	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12H	10-X611	UF Skid 12 Backwash Supply Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12H	10-X611	UF Skid 12 Backwash Supply Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12I	10-X611	UF Skid 12 Backwash Supply Drain Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12I	10-X611	UF Skid 12 Backwash Supply Drain Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12J	10-X611	UF Skid 12 UF Filtrate Block Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12J	10-X611	UF Skid 12 UF Filtrate Block Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12K	10-X611	UF Skid 12 UF Filtrate Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12K	10-X611	UF Skid 12 UF Filtrate Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12L	10-X611	UF Skid 12 UF Filtrate Drain Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12L	10-X611	UF Skid 12 UF Filtrate Drain Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12M	10-X611	UF Skid 12 UF Filtrate CIP Return Block Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12M	10-X611	UF Skid 12 UF Filtrate CIP Return Block Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12N	10-X611	UF Skid 12 UF Filtrate CIP Return Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12N	10-X611	UF Skid 12 UF Filtrate CIP Return Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12O	10-X611	UF Skid 12 UF Filtrate CIP Return Drain Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12O	10-X611	UF Skid 12 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12P	10-X611	UF Skid 12 Backwash Waste CIP Return Block Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12P	10-X611	UF Skid 12 Backwash Waste CIP Return Block Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12Q	10-X611	UF Skid 12 Backwash Waste CIP Return Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12Q	10-X611	UF Skid 12 Backwash Waste CIP Return Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12R	10-X611	UF Skid 12 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12R	10-X611	UF Skid 12 Backwash Waste CIP Return Drain Valve Open	LCP-0203-12	ETH	By Vendor	

P25-ZL-0203-12S	10-X611	UF Skid 12 Backwash Waste Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12S	10-X611	UF Skid 12 Backwash Waste Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12T	10-X611	UF Skid 12 UF Filtrate Air Purge Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12T	10-X611	UF Skid 12 UF Filtrate Air Purge Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12U	10-X611	UF Skid 12 Backwash Waste Air Purge Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12U	10-X611	UF Skid 12 Backwash Waste Air Purge Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12V	10-X611	UF Skid 12 Drain Down Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12V	10-X611	UF Skid 12 Drain Down Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12W	10-X611	UF Skid 12 Turbidimeter Sample Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12W	10-X611	UF Skid 12 Turbidimeter Sample Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12X	10-X611	UF Skid 12 Air Scour Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12X	10-X611	UF Skid 12 Air Scour Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZH-0203-12Y	10-X611	UF Skid 12 PDT Air Valve Open	LCP-0203-12	ETH	By Vendor	
P25-ZL-0203-12Y	10-X611	UF Skid 12 PDT Air Valve Closed	LCP-0203-12	ETH	By Vendor	
P25-TI-0203-8	10-X611	UF Skid 8 Water Temperature	LCP-0203-8	ETH	By Vendor	
P25-FI-0203-8	10-X611	UF Skid 8 Filtrate Flow	LCP-0203-8	ETH	By Vendor	
P25-PDI-0203-8	10-X611	UF Skid 8 Transmembrane Pressure	LCP-0203-8	ETH	By Vendor	
P25-XA-0203-8	10-X611	UF Skid 8 General Alarm	LCP-0203-8	ETH	By Vendor	
P25-PI-0203-8A	10-X611	UF Skid 8 Feed Pressure	LCP-0203-8	ETH	By Vendor	
P25-AI-0203-8A	10-X611	UF Skid 8 Normalized Permeability	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8A	10-X611	UF Skid 8 UF Feed Block Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8A	10-X611	UF Skid 8 UF Feed Block Valve Open	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8A	10-X611	UF Skid 8 in Production Mode	LCP-0203-8	ETH	By Vendor	
P25-PI-0203-8B	10-X611	UF Skid 8 Filtrate Pressure	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8B	10-X611	UF Skid 8 UF Feed Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8B	10-X611	UF Skid 8 UF Feed Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-AI-0203-8B	10-X611	UF Skid 8 Membrane Flux	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8B	10-X611	UF Skid 8 in Backwash Mode	LCP-0203-8	ETH	By Vendor	
P25-AI-0203-8C	10-X611	UF Skid 8 Filtrate Turbidity	LCP-0203-8	ETH	By Vendor	
P25-PI-0203-8C	10-X611	UF Skid 8 Air System Pressure	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8C	10-X611	UF Skid 8 UF Feed Drain Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8C	10-X611	UF Skid 8 UF Feed Drain Valve Open	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8C	10-X611	UF Skid 8 in Maintenance Clean Mode	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8D	10-X611	UF Skid 8 CIP Supply Block Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8D	10-X611	UF Skid 8 CIP Supply Block Valve Open	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8D	10-X611	UF Skid 8 in CIP Mode	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8E	10-X611	UF Skid 8 CIP Supply Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8E	10-X611	UF Skid 8 CIP Supply Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8E	10-X611	UF Skid 8 Integrity Test	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8F	10-X611	UF Skid 8 in Standby	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8F	10-X611	UF Skid 8 CIP Supply Drain Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8F	10-X611	UF Skid 8 CIP Supply Drain Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8G	10-X611	UF Skid 8 Backwash Supply Block Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8G	10-X611	UF Skid 8 Backwash Supply Block Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-YI-0203-8G	10-X611	UF Skid 8 Offline	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8H	10-X611	UF Skid 8 Backwash Supply Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8H	10-X611	UF Skid 8 Backwash Supply Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8I	10-X611	UF Skid 8 Backwash Supply Drain Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8I	10-X611	UF Skid 8 Backwash Supply Drain Valve Closed	LCP-0203-8	ETH	By Vendor	

P25-ZL-0203-8J	10-X611	UF Skid 8 UF Filtrate Block Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8J	10-X611	UF Skid 8 UF Filtrate Block Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8K	10-X611	UF Skid 8 UF Filtrate Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8K	10-X611	UF Skid 8 UF Filtrate Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8L	10-X611	UF Skid 8 UF Filtrate Drain Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8L	10-X611	UF Skid 8 UF Filtrate Drain Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8M	10-X611	UF Skid 8 UF Filtrate CIP Return Block Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8M	10-X611	UF Skid 8 UF Filtrate CIP Return Block Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8N	10-X611	UF Skid 8 UF Filtrate CIP Return Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8N	10-X611	UF Skid 8 UF Filtrate CIP Return Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8O	10-X611	UF Skid 8 UF Filtrate CIP Return Drain Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8O	10-X611	UF Skid 8 UF Filtrate CIP Return Drain Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8P	10-X611	UF Skid 8 Backwash Waste CIP Return Block Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8P	10-X611	UF Skid 8 Backwash Waste CIP Return Block Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8Q	10-X611	UF Skid 8 Backwash Waste CIP Return Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8Q	10-X611	UF Skid 8 Backwash Waste CIP Return Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8R	10-X611	UF Skid 8 Backwash Waste CIP Return Drain Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8R	10-X611	UF Skid 8 Backwash Waste CIP Return Drain Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8S	10-X611	UF Skid 8 Backwash Waste Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8S	10-X611	UF Skid 8 Backwash Waste Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8T	10-X611	UF Skid 8 UF Filtrate Air Purge Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8T	10-X611	UF Skid 8 UF Filtrate Air Purge Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8U	10-X611	UF Skid 8 Backwash Waste Air Purge Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8U	10-X611	UF Skid 8 Backwash Waste Air Purge Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8V	10-X611	UF Skid 8 Drain Down Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8V	10-X611	UF Skid 8 Drain Down Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8W	10-X611	UF Skid 8 Turbidimeter Sample Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8W	10-X611	UF Skid 8 Turbidimeter Sample Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8X	10-X611	UF Skid 8 Air Scour Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8X	10-X611	UF Skid 8 Air Scour Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZL-0203-8Y	10-X611	UF Skid 8 PDT Air Valve Closed	LCP-0203-8	ETH	By Vendor	
P25-ZH-0203-8Y	10-X611	UF Skid 8 PDT Air Valve Open	LCP-0203-8	ETH	By Vendor	
P25-ZH-0221-2A	10-X612	CIP Skid 1 Chlorine Solution Supply Valve Open	PLC-0000-1	DI	Bool	
P25-IR-0221-2A	10-X612	CIP Skid 1 Chlorine Solution Supply Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0221-2A	10-X612	CIP Skid 1 Chlorine Solution Supply Valve Closed	PLC-0000-1	DI	Bool	
P25-ZF-0221-2A	10-X612	CIP Skid 1 Chlorine Solution Supply Valve Fault	PLC-0000-1	DI	Bool	
P25-ZB-0221-2A	10-X612	CIP Skid 1 Chlorine Solution Supply Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0221-2A	10-X612	CIP Skid 1 Chlorine Solution Supply Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-LI-0221-1	10-X612	CIP Tank 1 Level	LCP-0221-1	ETH	By Vendor	
P25-TI-0221-1	10-X612	CIP Tank 1 Temperature	LCP-0221-1	ETH	By Vendor	
P25-XA-0221-1	10-X612	CIP Skid 1 System Trouble	LCP-0221-1	ETH	By Vendor	
P25-PI-0226-1	10-X612	CIP Skid 1 Air Pressure	LCP-0221-1	ETH	By Vendor	
P25-ZH-0221-1A	10-X612	CIP Tank 1 CIP Return Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0221-1A	10-X612	CIP Tank 1 CIP Return Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZH-0221-1C	10-X612	CIP Tank 1 UF Filtrate Supply Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZF-0221-1C	10-X612	CIP Tank 1 UF Filtrate Supply Valve Fault	LCP-0221-1	ETH	By Vendor	
P25-IR-0221-1C	10-X612	CIP Tank 1 UF Filtrate Supply Valve In Remote	LCP-0221-1	ETH	By Vendor	
P25-ZL-0221-1C	10-X612	CIP Tank 1 UF Filtrate Supply Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-MN-0221-2	10-X612	CIP Pump 1 Running	LCP-0221-1	ETH	By Vendor	

P25-SI-0221-2	10-X612	CIP Pump 1 Speed Indication	LCP-0221-1	ETH	By Vendor	
P25-MO-0221-2	10-X612	CIP Pump 1 Overload Fault	LCP-0221-1	ETH	By Vendor	
P25-AI-0221-2	10-X612	CIP Skid 1 pH	LCP-0221-1	ETH	By Vendor	
P25-XF-0221-2	10-X612	CIP Pump 1 VFD Fault	LCP-0221-1	ETH	By Vendor	
P25-SC-0221-2	10-X612	CIP Pump 1 Speed Command	LCP-0221-1	ETH	By Vendor	
P25-IR-0221-2	10-X612	CIP Pump 1 In Remote	LCP-0221-1	ETH	By Vendor	
P25-PI-0221-2	10-X612	CIP Pump 1 Discharge Pressure to UF Skids	LCP-0221-1	ETH	By Vendor	
P25-MD-0221-2	10-X612	CIP Pump 1 Command Start	LCP-0221-1	ETH	By Vendor	
P25-MY-0221-2	10-X612	CIP Pump 1 Emergency Stop	LCP-0221-1	ETH	By Vendor	
P25-ZL-0221-2C	10-X612	CIP Skid 1 CIP Supply Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZH-0221-2C	10-X612	CIP Skid 1 CIP Supply Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZH-0221-2D	10-X612	CIP Skid 1 CIP Return Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0221-2D	10-X612	CIP Skid 1 CIP Return Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZL-0221-2F	10-X612	CIP Tank 1 CIP Return Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZH-0221-2F	10-X612	CIP Tank 1 CIP Return Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZH-0221-2G	10-X612	CIP Pump 1 Discharge Drain Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0221-2G	10-X612	CIP Pump 1 Discharge Drain Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-FI-0221-3	10-X612	CIP Tank 1 Discharge Flow	LCP-0221-1	ETH	By Vendor	
P25-PI-0221-4	10-X612	CIP Pump 1 Discharge Pressure	LCP-0221-1	ETH	By Vendor	
P25-ZF-0222-2A	10-X613	CIP Skid 2 Chlorine Solution Supply Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0222-2A	10-X613	CIP Skid 2 Chlorine Solution Supply Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0222-2A	10-X613	CIP Skid 2 Chlorine Solution Supply Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0222-2A	10-X613	CIP Skid 2 Chlorine Solution Supply Valve Open	PLC-0000-1	DI	Bool	
P25-ZB-0222-2A	10-X613	CIP Skid 2 Chlorine Solution Supply Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0222-2A	10-X613	CIP Skid 2 Chlorine Solution Supply Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-XA-0222-1	10-X613	CIP Skid 2 System Trouble	LCP-0221-1	ETH	By Vendor	
P25-LI-0222-1	10-X613	CIP Tank 2 Level	LCP-0221-1	ETH	By Vendor	
P25-PI-0230-1	10-X613	CIP Skid 2 Air Pressure	LCP-0221-1	ETH	By Vendor	
P25-TI-0222-1	10-X613	CIP Tank 2 Temperature	LCP-0221-1	ETH	By Vendor	
P25-ZH-0222-1A	10-X613	CIP Tank 2 CIP Return Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0222-1A	10-X613	CIP Tank 2 CIP Return Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZF-0222-1C	10-X613	CIP Tank 2 UF Filtrate Supply Valve Fault	LCP-0221-1	ETH	By Vendor	
P25-IR-0222-1C	10-X613	CIP Tank 2 UF Filtrate Supply Valve In Remote	LCP-0221-1	ETH	By Vendor	
P25-ZH-0222-1C	10-X613	CIP Tank 2 UF Filtrate Supply Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0222-1C	10-X613	CIP Tank 2 UF Filtrate Supply Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-IR-0222-2	10-X613	CIP Pump 2 In Remote	LCP-0221-1	ETH	By Vendor	
P25-MN-0222-2	10-X613	CIP Pump 2 Running	LCP-0221-1	ETH	By Vendor	
P25-XF-0222-2	10-X613	CIP Pump 2 VFD Fault	LCP-0221-1	ETH	By Vendor	
P25-SI-0222-2	10-X613	CIP Pump 2 Speed Indication	LCP-0221-1	ETH	By Vendor	
P25-MO-0222-2	10-X613	CIP Pump 2 Overload Fault	LCP-0221-1	ETH	By Vendor	
P25-AI-0222-2	10-X613	CIP Skid 2 pH	LCP-0221-1	ETH	By Vendor	
P25-SC-0222-2	10-X613	CIP Pump 2 Speed Command	LCP-0221-1	ETH	By Vendor	
P25-PI-0222-2	10-X613	CIP Pump 2 Discharge Pressure to UF Skids	LCP-0221-1	ETH	By Vendor	
P25-MD-0222-2	10-X613	CIP Pump 2 Command Start	LCP-0221-1	ETH	By Vendor	
P25-MY-0222-2	10-X613	CIP Pump 2 Emergency Stop	LCP-0221-1	ETH	By Vendor	
P25-ZH-0222-2C	10-X613	CIP Skid 2 CIP Supply Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0222-2C	10-X613	CIP Skid 2 CIP Supply Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZL-0222-2D	10-X613	CIP Skid 2 CIP Return Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZH-0222-2D	10-X613	CIP Skid 2 CIP Return Valve Open	LCP-0221-1	ETH	By Vendor	

P25-ZH-0222-2F	10-X613	CIP Tank 2 CIP Return Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0222-2F	10-X613	CIP Tank 2 CIP Return Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-ZH-0222-2G	10-X613	CIP Pump 2 Discharge Drain Valve Open	LCP-0221-1	ETH	By Vendor	
P25-ZL-0222-2G	10-X613	CIP Pump 2 Discharge Drain Valve Closed	LCP-0221-1	ETH	By Vendor	
P25-FI-0222-3	10-X613	CIP Tank 1 Discharge Flow	LCP-0221-1	ETH	By Vendor	
P25-PI-0222-4	10-X613	CIP Pump 2 Discharge Pressure	LCP-0221-1	ETH	By Vendor	
P25-LI-0250-1	10-X614	Backwash Tank Cell 1 Level	PLC-0000-1	AI	0 - 11.5 FT	
P25-LI-0250-2	10-X614	Backwash Tank Cell 2 Level	PLC-0000-1	AI	0 - 11.5 FT	
P25-LI-0250-3	10-X614	Backwash Tank Cell 3 Level	PLC-0000-1	AI	0 - 11.5 FT	
P25-LAH-0250-1	10-X614	Backwash Tank Cell 1 Level Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0250-1A	10-X614	Backwash Tank Cell 1 Strainer Backwash Influent Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0250-1A	10-X614	Backwash Tank Cell 1 Strainer Backwash Influent Valve Closed	PLC-0000-1	DI	Bool	
P25-ZF-0250-1A	10-X614	Backwash Tank Cell 1 Strainer Backwash Influent Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0250-1A	10-X614	Backwash Tank Cell 1 Strainer Backwash Influent Valve Open	PLC-0000-1	DI	Bool	
P25-ZH-0250-1B	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 1 Open	PLC-0000-1	DI	Bool	
P25-ZL-0250-1B	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 1 Closed	PLC-0000-1	DI	Bool	
P25-IR-0250-1B	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 1 In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0250-1B	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 1 Fault	PLC-0000-1	DI	Bool	
P25-ZF-0250-1C	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 2 Fault	PLC-0000-1	DI	Bool	
P25-ZH-0250-1C	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 2 Open	PLC-0000-1	DI	Bool	
P25-IR-0250-1C	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 2 In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0250-1C	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 2 Closed	PLC-0000-1	DI	Bool	
P25-ZF-0250-1D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0250-1D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0250-1D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Open	PLC-0000-1	DI	Bool	
P25-ZL-0250-1D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Closed	PLC-0000-1	DI	Bool	
P25-ZF-0250-1E	10-X614	Backwash Tank Cell 1 Decanter Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0250-1E	10-X614	Backwash Tank Cell 1 Decanter Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0250-1E	10-X614	Backwash Tank Cell 1 Decanter Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-1E	10-X614	Backwash Tank Cell 1 Decanter Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-1F	10-X614	Backwash Tank Cell 1 Sludge Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZL-0250-1F	10-X614	Backwash Tank Cell 1 Sludge Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-1F	10-X614	Backwash Tank Cell 1 Sludge Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-IR-0250-1F	10-X614	Backwash Tank Cell 1 Sludge Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-LAH-0250-2	10-X614	Backwash Tank Cell 2 Level Alarm High	PLC-0000-1	DI	Bool	
P25-ZL-0250-2A	10-X614	Backwash Tank Cell 2 Strainer Backwash Influent Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0250-2A	10-X614	Backwash Tank Cell 2 Strainer Backwash Influent Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0250-2A	10-X614	Backwash Tank Cell 2 Strainer Backwash Influent Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0250-2A	10-X614	Backwash Tank Cell 2 Strainer Backwash Influent Valve Open	PLC-0000-1	DI	Bool	
P25-IR-0250-2B	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 1 In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0250-2B	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 1 Open	PLC-0000-1	DI	Bool	
P25-ZL-0250-2B	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 1 Closed	PLC-0000-1	DI	Bool	
P25-ZF-0250-2B	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 1 Fault	PLC-0000-1	DI	Bool	
P25-IR-0250-2C	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 2 In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0250-2C	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 2 Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-2C	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 2 Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-2C	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 2 Fault	PLC-0000-1	DI	Bool	
P25-ZL-0250-2D	10-X614	Backwash Tank Cell 2 Backwash Drain Influent Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0250-2D	10-X614	Backwash Tank Cell 2 Backwash Drain Influent Valve In Remote	PLC-0000-1	DI	Bool	

P25-ZH-0250-2D	10-X614	Backwash Tank Cell 2 Backwash Drain Influent Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-2D	10-X614	Backwash Tank Cell 2 Backwash Drain Influent Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0250-2E	10-X614	Backwash Tank Cell 2 Decanter Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0250-2E	10-X614	Backwash Tank Cell 2 Decanter Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZL-0250-2E	10-X614	Backwash Tank Cell 2 Decanter Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-2E	10-X614	Backwash Tank Cell 2 Decanter Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-IR-0250-2F	10-X614	Backwash Tank Cell 2 Sludge Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0250-2F	10-X614	Backwash Tank Cell 2 Sludge Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZL-0250-2F	10-X614	Backwash Tank Cell 2 Sludge Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZF-0250-2F	10-X614	Backwash Tank Cell 2 Sludge Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-LAH-0250-3	10-X614	Backwash Tank Cell 3 Level Alarm High	PLC-0000-1	DI	Bool	
P25-ZL-0250-3A	10-X614	Backwash Tank Cell 3 Strainer Backwash Influent Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-3A	10-X614	Backwash Tank Cell 3 Strainer Backwash Influent Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-3A	10-X614	Backwash Tank Cell 3 Strainer Backwash Influent Valve Fault	PLC-0000-1	DI	Bool	
P25-IR-0250-3A	10-X614	Backwash Tank Cell 3 Strainer Backwash Influent Valve In Remote	PLC-0000-1	DI	Bool	
P25-IR-0250-3B	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 1 In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0250-3B	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 1 Fault	PLC-0000-1	DI	Bool	
P25-ZH-0250-3B	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 1 Open	PLC-0000-1	DI	Bool	
P25-ZL-0250-3B	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 1 Closed	PLC-0000-1	DI	Bool	
P25-IR-0250-3C	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 2 In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0250-3C	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 2 Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-3C	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 2 Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-3C	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 2 Fault	PLC-0000-1	DI	Bool	
P25-IR-0250-3D	10-X614	Backwash Tank Cell 3 Backwash Drain Influent Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0250-3D	10-X614	Backwash Tank Cell 3 Backwash Drain Influent Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-3D	10-X614	Backwash Tank Cell 3 Backwash Drain Influent Valve Fault	PLC-0000-1	DI	Bool	
P25-ZL-0250-3D	10-X614	Backwash Tank Cell 3 Backwash Drain Influent Valve Closed	PLC-0000-1	DI	Bool	
P25-ZH-0250-3E	10-X614	Backwash Tank Cell 3 Decanter Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-3E	10-X614	Backwash Tank Cell 3 Decanter Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZL-0250-3E	10-X614	Backwash Tank Cell 3 Decanter Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0250-3E	10-X614	Backwash Tank Cell 3 Decanter Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0250-3F	10-X614	Backwash Tank Cell 3 Sludge Discharge Valve Closed	PLC-0000-1	DI	Bool	
P25-IR-0250-3F	10-X614	Backwash Tank Cell 3 Sludge Discharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0250-3F	10-X614	Backwash Tank Cell 3 Sludge Discharge Valve Open	PLC-0000-1	DI	Bool	
P25-ZF-0250-3F	10-X614	Backwash Tank Cell 3 Sludge Discharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZD-0250-1A	10-X614	Backwash Tank Cell 1 Strainer Backwash Influent Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-1A	10-X614	Backwash Tank Cell 1 Strainer Backwash Influent Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-1B	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-1B	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 1 Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-1C	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-1C	10-X614	Backwash Tank Cell 1 Air Purge Influent Valve 2 Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZB-0250-1D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-1D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-1E	10-X614	Backwash Tank Cell 1 Decanter Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-1E	10-X614	Backwash Tank Cell 1 Decanter Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0250-1F	10-X614	Backwash Tank Cell 1 Sludge Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-1F	10-X614	Backwash Tank Cell 1 Sludge Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0250-2A	10-X614	Backwash Tank Cell 2 Strainer Backwash Influent Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-2A	10-X614	Backwash Tank Cell 2 Strainer Backwash Influent Valve Command Open	PLC-0000-1	DO	1 = Open	

P25-ZB-0250-2B	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 1 Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-2B	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-2C	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 2 Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-2C	10-X614	Backwash Tank Cell 2 Air Purge Influent Valve 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0250-2D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-2D	10-X614	Backwash Tank Cell 1 Backwash Drain Influent Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-2E	10-X614	Backwash Tank Cell 2 Decanter Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-2E	10-X614	Backwash Tank Cell 2 Decanter Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-2F	10-X614	Backwash Tank Cell 2 Sludge Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-2F	10-X614	Backwash Tank Cell 2 Sludge Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-3A	10-X614	Backwash Tank Cell 3 Strainer Backwash Influent Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-3A	10-X614	Backwash Tank Cell 3 Strainer Backwash Influent Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0250-3B	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 1 Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-3B	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZD-0250-3C	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-3C	10-X614	Backwash Tank Cell 3 Air Purge Influent Valve 2 Command Closed	PLC-0000-1	DO	1 = Close	
P25-ZB-0250-3D	10-X614	Backwash Tank Cell 3 Backwash Drain Influent Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-3D	10-X614	Backwash Tank Cell 3 Backwash Drain Influent Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-3E	10-X614	Backwash Tank Cell 3 Decanter Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-3E	10-X614	Backwash Tank Cell 3 Decanter Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0250-3F	10-X614	Backwash Tank Cell 3 Sludge Discharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0250-3F	10-X614	Backwash Tank Cell 3 Sludge Discharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-SI-0251-1	10-X615	Backwash Recycle Pump 1 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-FI-0251-1	10-X615	Backwash Recycle Pumps Discharge Flow	PLC-0000-1	AI	0 - 2100 GPM	
P25-SI-0252-1	10-X615	Backwash Sludge Pump 1 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0251-2	10-X615	Backwash Recycle Pump 2 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0252-2	10-X615	Backwash Sludge Pump 2 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0251-3	10-X615	Backwash Recycle Pump 3 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0251-4	10-X615	Backwash Recycle Pump 4 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SC-0251-1	10-X615	Backwash Recycle Pump 1 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0252-1	10-X615	Backwash Sludge Pump 1 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0252-2	10-X615	Backwash Sludge Pump 2 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0251-2	10-X615	Backwash Recycle Pump 2 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0251-3	10-X615	Backwash Recycle Pump 3 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0251-4	10-X615	Backwash Recycle Pump 4 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-MN-0251-1	10-X615	Backwash Recycle Pump 1 Running	RIO-0000-1	DI	Bool	
P25-XF-0251-1	10-X615	Backwash Recycle Pump 1 VFD Fault	RIO-0000-1	DI	Bool	
P25-MY-0251-1	10-X615	Backwash Recycle Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MO-0252-1	10-X615	Backwash Sludge Pump 1 Overload	RIO-0000-1	DI	Bool	
P25-IR-0252-1	10-X615	Backwash Sludge Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0252-1	10-X615	Backwash Sludge Pump 1 Running	RIO-0000-1	DI	Bool	
P25-PAL-0251-1	10-X615	Backwash Recycle Pump 1 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-XF-0252-1	10-X615	Backwash Sludge Pump 1 VFD Fault	RIO-0000-1	DI	Bool	
P25-MY-0252-1	10-X615	Backwash Sludge Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0251-1	10-X615	Backwash Recycle Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-IR-0251-2	10-X615	Backwash Recycle Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0252-2	10-X615	Backwash Sludge Pump 2 Running	RIO-0000-1	DI	Bool	
P25-XF-0252-2	10-X615	Backwash Sludge Pump 2 VFD Fault	RIO-0000-1	DI	Bool	
P25-XF-0251-2	10-X615	Backwash Recycle Pump 2 VFD Fault	RIO-0000-1	DI	Bool	

P25-PAL-0251-2	10-X615	Backwash Recycle Pump 2 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MY-0251-2	10-X615	Backwash Recycle Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MO-0252-2	10-X615	Backwash Sludge Pump 2 Overload	RIO-0000-1	DI	Bool	
P25-MN-0251-2	10-X615	Backwash Recycle Pump 2 Running	RIO-0000-1	DI	Bool	
P25-MY-0252-2	10-X615	Backwash Sludge Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0252-2	10-X615	Backwash Sludge Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-PAL-0251-3	10-X615	Backwash Recycle Pump 3 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-IR-0251-3	10-X615	Backwash Recycle Pump 3 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0251-3	10-X615	Backwash Recycle Pump 3 Emergency Stop	RIO-0000-1	DI	Bool	
P25-XF-0251-3	10-X615	Backwash Recycle Pump 3 VFD Fault	RIO-0000-1	DI	Bool	
P25-MN-0251-3	10-X615	Backwash Recycle Pump 3 Running	RIO-0000-1	DI	Bool	
P25-PAL-0251-4	10-X615	Backwash Recycle Pump 4 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MY-0251-4	10-X615	Backwash Recycle Pump 4 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0251-4	10-X615	Backwash Recycle Pump 4 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0251-4	10-X615	Backwash Recycle Pump 4 Running	RIO-0000-1	DI	Bool	
P25-XF-0251-4	10-X615	Backwash Recycle Pump 4 VFD Fault	RIO-0000-1	DI	Bool	
P25-MD-0252-1	10-X615	Backwash Sludge Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0251-1	10-X615	Backwash Recycle Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0252-2	10-X615	Backwash Sludge Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0251-2	10-X615	Backwash Recycle Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0251-3	10-X615	Backwash Recycle Pump 3 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0251-4	10-X615	Backwash Recycle Pump 4 Command Start	RIO-0000-1	DO	1 = Start	
P25-LI-0253-1	10-X616	Chemical Waste Tank Level	PLC-0000-1	AI	0 - 11.5 FT	
P25-AI-0254-1	10-X616	CIP Waste & Backwash Sludge pH	PLC-0000-1	AI	0.0 - 14.0	
P25-FI-0253-2	10-X616	CIP Waste Pumps Discharge Flow	PLC-0000-1	AI	0 - 60 GPM	
P25-AI-0254-2	10-X616	CIP Waste & Backwash Sludge ORP	PLC-0000-1	AI	-1500 - 1500 mV	
P25-FI-0253-3	10-X616	Backwash Sludge Pumps Discharge Flow	PLC-0000-1	AI	0 - 300 GPM	
P25-PAL-0253-1	10-X616	CIP Waste Pump 1 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MY-0253-1	10-X616	CIP Waste Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MN-0253-1	10-X616	CIP Waste Pump 1 Running	RIO-0000-1	DI	Bool	
P25-MO-0253-1	10-X616	CIP Waste Pump 1 Overload	RIO-0000-1	DI	Bool	
P25-IR-0253-1	10-X616	CIP Waste Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-LAH-0253-1	10-X616	Chemical Waste Tank Level Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0253-1A	10-X616	CIP Waste Pumps Dicharge Valve In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0253-1A	10-X616	CIP Waste Pumps Dicharge Valve Closed	PLC-0000-1	DI	Bool	
P25-ZF-0253-1A	10-X616	CIP Waste Pumps Dicharge Valve Fault	PLC-0000-1	DI	Bool	
P25-ZH-0253-1A	10-X616	CIP Waste Pumps Dicharge Valve Open	PLC-0000-1	DI	Bool	
P25-MY-0253-2	10-X616	CIP Waste Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0253-2	10-X616	CIP Waste Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0253-2	10-X616	CIP Waste Pump 2 Running	RIO-0000-1	DI	Bool	
P25-PAL-0253-2	10-X616	CIP Waste Pump 2 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MO-0253-2	10-X616	CIP Waste Pump 2 Overload	RIO-0000-1	DI	Bool	
P25-MD-0253-1	10-X616	CIP Waste Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZB-0253-1A	10-X616	CIP Waste Pumps Dicharge Valve Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0253-1A	10-X616	CIP Waste Pumps Dicharge Valve Command Open	PLC-0000-1	DO	1 = Open	
P25-MD-0253-2	10-X616	CIP Waste Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-MO-0231-1	10-X617	Compressor 1 Overload	MCP-0200-1	ETH	By Vendor	
P25-MN-0231-1	10-X617	Compressor 1 Running	MCP-0200-1	ETH	By Vendor	
P25-PI-0234-1	10-X617	Air Supply Header Pressure	MCP-0200-1	ETH	By Vendor	

P25-MD-0231-1	10-X617	Compressor 1 Command Start	MCP-0200-1	ETH	By Vendor	
P25-MN-0231-2	10-X617	Compressor 2 Running	MCP-0200-1	ETH	By Vendor	
P25-MO-0231-2	10-X617	Compressor 2 Overload	MCP-0200-1	ETH	By Vendor	
P25-MD-0231-2	10-X617	Compressor 2 Command Start	MCP-0200-1	ETH	By Vendor	
P25-MN-0231-3	10-X617	Compressor 3 Running	MCP-0200-1	ETH	By Vendor	
P25-MD-0231-3	10-X617	Compressor 3 Command Start	MCP-0200-1	ETH	By Vendor	
P25-MO-0231-3	10-X617	Compressor 3 Overload	MCP-0200-1	ETH	By Vendor	
P25-ZB-0232-5A	10-X617	Air Dryer 2 Drain Solenoid Valve Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0231-5A	10-X617	Air Dryer 1 Drain Solenoid Valve Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0231-5A	10-X617	Air Dryer 1 Drain Solenoid Valve Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0232-5A	10-X617	Air Dryer 2 Drain Solenoid Valve Command Open	MCP-0200-1	ETH	By Vendor	
P25-PAL-0231-7	10-X617	Secondary Air Receiver 1 Pressure Alarm Low	MCP-0200-1	ETH	By Vendor	
P25-PAL-0232-7	10-X617	Secondary Air Receiver 2 Pressure Alarm Low	MCP-0200-1	ETH	By Vendor	
P25-PAH-0232-7	10-X617	Secondary Air Receiver 2 Pressure Alarm High	MCP-0200-1	ETH	By Vendor	
P25-PAH-0231-7	10-X617	Secondary Air Receiver 1 Pressure Alarm High	MCP-0200-1	ETH	By Vendor	
P25-ZD-0232-7A	10-X617	Secondary Air Receiver 2 Drain Valve Solenoid Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0231-7A	10-X617	Secondary Air Receiver 1 Drain Valve Solenoid Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0231-7A	10-X617	Secondary Air Receiver 1 Drain Valve Solenoid Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0232-7A	10-X617	Secondary Air Receiver 2 Drain Valve Solenoid Command Close	MCP-0200-1	ETH	By Vendor	
P25-WI-0301-1	10-X618	Chlorine Gas Scale 1 Weight	PLC-0000-1	AI	0 - 4000 LB	
P25-AAH-0300-1	10-X618	Chlorine Room Analyzer 1 Chlorine Content Warning	PLC-0000-1	AI	Bool	
P25-AI-0300-1	10-X618	Chlorine Room Analyzer 1 Chlorine Content	PLC-0000-1	AI	0 - 10 ppm	
P25-AI-0300-2	10-X618	Chlorine Room Analyzer 2 Chlorine Content	PLC-0000-1	AI	0 - 10 ppm	
P25-AAH-0300-2	10-X618	Chlorine Room Analyzer 2 Chlorine Content Warning	PLC-0000-1	AI	Bool	
P25-WI-0301-2	10-X618	Chlorine Gas Scale 2 Weight	PLC-0000-1	AI	0 - 4000 LB	
P25-PAH-0301-3	10-X618	Chlorine Gas Header Pressure Alarm High	PLC-0000-1	AI	Bool	
P25-WI-0301-3	10-X618	Chlorine Gas Scale 3 Weight	PLC-0000-1	AI	0 - 4000 LB	
P25-ZI-0301-4	10-X618	Chlorinator 1 Position	PLC-0000-1	AI	0 - 100%	
P25-PAH-0301-4	10-X618	Chlorinator 1 Discharge Pressure Alarm High	PLC-0000-1	AI	Bool	
P25-PAH-0301-5	10-X618	Chlorinator 2 Discharge Pressure Alarm High	PLC-0000-1	AI	Bool	
P25-ZI-0301-5	10-X618	Chlorinator 2 Position	PLC-0000-1	AI	0 - 100%	
P25-ZI-0301-6	10-X618	Chlorinator 3 Position	PLC-0000-1	AI	0 - 100%	
P25-PAH-0301-6	10-X618	Chlorinator 3 Discharge Pressure Alarm High	PLC-0000-1	AI	Bool	
P25-ZI-0301-7	10-X618	Chlorinator 4 Position	PLC-0000-1	AI	0 - 100%	
P25-PAH-0301-7	10-X618	Chlorinator 4 Discharge Pressure Alarm High	PLC-0000-1	AI	Bool	
P25-IR-0301-4	10-X618	Chlorinator 1 In Remote	PLC-0000-1	DI	Bool	
P25-IR-0301-5	10-X618	Chlorinator 2 In Remote	PLC-0000-1	DI	Bool	
P25-IR-0301-6	10-X618	Chlorinator 3 In Remote	PLC-0000-1	DI	Bool	
P25-IR-0301-7	10-X618	Chlorinator 4 In Remote	PLC-0000-1	DI	Bool	
P25-ZD-0301-4	10-X618	Chlorinator 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0301-4	10-X618	Chlorinator 1 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0301-5	10-X618	Chlorinator 2 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0301-5	10-X618	Chlorinator 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0301-6	10-X618	Chlorinator 3 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0301-6	10-X618	Chlorinator 3 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0301-7	10-X618	Chlorinator 4 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0301-7	10-X618	Chlorinator 4 Command Open	PLC-0000-1	DO	1 = Open	
P25-FI-0302-10	10-X619	Chlorinator Booster Pumps 3 & 4 Discharge Flow	PLC-0000-1	AI	0 - 15 GPM	
P25-FI-0301-8	10-X619	Chlorinator Booster Pumps 1 & 2 Discharge Flow	PLC-0000-1	AI	0 - 30 GPM	

P25-MO-0301-10	10-X619	Chlorinator Booster Pump 3 Overload	RIO-0000-1	DI	Bool	
P25-IR-0301-10	10-X619	Chlorinator Booster Pump 3 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0301-10	10-X619	Chlorinator Booster Pump 3 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MN-0301-10	10-X619	Chlorinator Booster Pump 3 Running	RIO-0000-1	DI	Bool	
P25-MY-0301-11	10-X619	Chlorinator Booster Pump 4 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MO-0301-11	10-X619	Chlorinator Booster Pump 4 Overload	RIO-0000-1	DI	Bool	
P25-IR-0301-11	10-X619	Chlorinator Booster Pump 4 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0301-11	10-X619	Chlorinator Booster Pump 4 Running	RIO-0000-1	DI	Bool	
P25-MN-0301-8	10-X619	Chlorinator Booster Pump 1 Running	RIO-0000-1	DI	Bool	
P25-MY-0301-8	10-X619	Chlorinator Booster Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-IR-0301-8	10-X619	Chlorinator Booster Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-MO-0301-8	10-X619	Chlorinator Booster Pump 1 Overload	RIO-0000-1	DI	Bool	
P25-IR-0301-9	10-X619	Chlorinator Booster Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0301-9	10-X619	Chlorinator Booster Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-MN-0301-9	10-X619	Chlorinator Booster Pump 2 Running	RIO-0000-1	DI	Bool	
P25-MO-0301-9	10-X619	Chlorinator Booster Pump 2 Overload	RIO-0000-1	DI	Bool	
P25-MD-0301-10	10-X619	Chlorinator Booster Pump 3 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0301-11	10-X619	Chlorinator Booster Pump 4 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0301-8	10-X619	Chlorinator Booster Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-MD-0301-9	10-X619	Chlorinator Booster Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-AAHH-0300-1	10-X620	Chlorine Room Chlorine Analyzer 1 Alarm	PLC-0000-1	DI	Bool	
P25-DPAH-0301-16	10-X620	Dry Scrubber Differential Pressure Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0301-17	10-X620	Exhaust Blower 1 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0301-17	10-X620	Exhaust Blower 1 Overload	PLC-0000-1	DI	Bool	
P25-MN-0301-17	10-X620	Exhaust Blower 1 Running	PLC-0000-1	DI	Bool	
P25-IR-0301-18	10-X620	Exhaust Blower 2 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0301-18	10-X620	Exhaust Blower 2 Overload	PLC-0000-1	DI	Bool	
P25-MN-0301-18	10-X620	Exhaust Blower 2 Running	PLC-0000-1	DI	Bool	
P25-AAHH-0300-2	10-X620	Chlorine Room Chlorine Analyzer 2 Alarm	PLC-0000-1	DI	Bool	
P25-MD-0301-17	10-X620	Exhaust Blower 1 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0301-18	10-X620	Exhaust Blower 2 Command Start	PLC-0000-1	DO	1 = Start	
P25-SI-0302-1	10-X621	Coagulant Metering Pump 1 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-LI-0302-1A	10-X621	Coagulant Storage Tank 1 Level	PLC-0000-1	AI	0 - 12 FT	
P25-LI-0302-2A	10-X621	Coagulant Storage Tank 2 Level	PLC-0000-1	AI	0 - 12 FT	
P25-SI-0302-2	10-X621	Coagulant Metering Pump 2 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-SI-0302-3	10-X621	Coagulant Metering Pump 3 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-SC-0302-1	10-X621	Coagulant Metering Pump 1 Speed Command	PLC-0000-1	AO	0 - 100%	
P25-SC-0302-2	10-X621	Coagulant Metering Pump 2 Speed Command	PLC-0000-1	AO	0 - 100%	
P25-SC-0302-3	10-X621	Coagulant Metering Pump 3 Speed Command	PLC-0000-1	AO	0 - 100%	
P25-LI-0302-1B	10-X621	Coagulant Storage Tank 1 Level Feedback	PLC-0000-1	AO	0 - 12 FT	
P25-LI-0302-2B	10-X621	Coagulant Storage Tank 2 Level Feedback	PLC-0000-1	AO	0 - 12 FT	
P25-MN-0302-1	10-X621	Coagulant Metering Pump 1 Running	PLC-0000-1	DI	Bool	
P25-IR-0302-1	10-X621	Coagulant Metering Pump 1 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0302-1A	10-X621	Coagulant Metering Pump 1 Overload	PLC-0000-1	DI	Bool	
P25-LAH-0302-1A	10-X621	Coagulant Storage Tank 1 Level Alarm High	PLC-0000-1	DI	Bool	
P25-MY-0302-1	10-X621	Coagulant Metering Pump 1 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MY-0302-2	10-X621	Coagulant Metering Pump 2 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MO-0302-2	10-X621	Coagulant Metering Pump 2 Overload	PLC-0000-1	DI	Bool	
P25-MN-0302-2	10-X621	Coagulant Metering Pump 2 Running	PLC-0000-1	DI	Bool	

P25-LAH-0302-2A	10-X621	Coagulant Storage Tank 2 Level Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0302-2	10-X621	Coagulant Metering Pump 2 In Remote	PLC-0000-1	DI	Bool	
P25-IR-0302-3	10-X621	Coagulant Metering Pump 3 In Remote	PLC-0000-1	DI	Bool	
P25-LAH-0302-3	10-X621	Coagulant Storage Area Sump Level Alarm High	PLC-0000-1	DI	Bool	
P25-MY-0302-3	10-X621	Coagulant Metering Pump 3 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MO-0302-3	10-X621	Coagulant Metering Pump 3 Overload	PLC-0000-1	DI	Bool	
P25-MN-0302-3	10-X621	Coagulant Metering Pump 3 Running	PLC-0000-1	DI	Bool	
P25-MD-0302-1	10-X621	Coagulant Metering Pump 1 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0302-2	10-X621	Coagulant Metering Pump 2 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0302-3	10-X621	Coagulant Metering Pump 3 Command Start	PLC-0000-1	DO	1 = Start	
P25-LAH-0302-1B	10-X621	Coagulant Storage Tank 1 Level Alarm High Indication	PLC-0000-1	DO	1 = High Level Alarm	
P25-LAH-0302-2B	10-X621	Coagulant Storage Tank 2 Level Alarm High Indication	PLC-0000-1	DO	1 = High Level Alarm	
P25-LI-0303-1A	10-X622	Sodium Bisulfite Tank Level	PLC-0000-1	AI	0 - 12 FT	
P25-SI-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-SI-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-SI-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Speed Indication	PLC-0000-1	AI	0 -100%	
P25-SI-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-SI-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Speed Indication	PLC-0000-1	AI	0 - 100%	
P25-SC-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Speed Command	PLC-0000-1	AO	Bool	
P25-SC-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Speed Command	PLC-0000-1	AO	0 - 100%	
P25-SC-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Speed Command	PLC-0000-1	AO	0 -100%	
P25-SC-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Speed Command	PLC-0000-1	AO	0 - 100%	
P25-SC-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Speed Command	PLC-0000-1	AO	0 - 100%	
P25-LI-0303-1B	10-X622	Sodium Bisulfite Tank Level Feedback	PLC-0000-1	AO	0 - 12 FT	
P25-MY-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Emergency Stop	PLC-0000-1	DI	Bool	
P25-IR-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Overload	PLC-0000-1	DI	Bool	
P25-MN-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Running	PLC-0000-1	DI	Bool	
P25-LAH-0303-1A	10-X622	Sodium Bisulfite Tank Level Alarm High	PLC-0000-1	DI	Bool	
P25-MO-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Overload	PLC-0000-1	DI	Bool	
P25-MN-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Running	PLC-0000-1	DI	Bool	
P25-IR-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 In Remote	PLC-0000-1	DI	Bool	
P25-MY-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Emergency Stop	PLC-0000-1	DI	Bool	
P25-LAH-0303-2	10-X622	Sodium Bisulfite Storage Area Sump Level Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 In Remote	PLC-0000-1	DI	Bool	
P25-MN-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Running	PLC-0000-1	DI	Bool	
P25-MO-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Overload	PLC-0000-1	DI	Bool	
P25-MY-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MY-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MN-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Running	PLC-0000-1	DI	Bool	
P25-IR-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Overload	PLC-0000-1	DI	Bool	
P25-MY-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Emergency Stop	PLC-0000-1	DI	Bool	
P25-IR-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Overload	PLC-0000-1	DI	Bool	
P25-MN-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Running	PLC-0000-1	DI	Bool	
P25-MD-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Command Start	PLC-0000-1	DO	1 = Start	
P25-ZD-0303-1A	10-X622	Carrier Water Solenoid 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0303-1A	10-X622	Carrier Water Solenoid 1 Command Close	PLC-0000-1	DO	1 = Close	

P25-MD-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Command Start	PLC-0000-1	DO	1 = Start	
P25-ZB-0303-3A	10-X622	Carrier Water Solenoid 2 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0303-3A	10-X622	Carrier Water Solenoid 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-MD-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Command Start	PLC-0000-1	DO	1 = Start	
P25-LAH-0303-1B	10-X622	Sodium Bisulfite Tank Level Alarm High Indication	PLC-0000-1	DO	1 = High Level Alarm	
P25-ZD-0304-1A	10-X623	Citric Acid Metering Pump 1 Air Intake Valve Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0304-1A	10-X623	Citric Acid Metering Pump 1 Air Intake Valve Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0304-2A	10-X623	Citric Acid Metering Pump 2 Air Intake Valve Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0304-2A	10-X623	Citric Acid Metering Pump 2 Air Intake Valve Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZB-0304-3A	10-X623	Citric Acid Discharge Valve to CIP Skid 1 Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0304-3A	10-X623	Citric Acid Discharge Valve to CIP Skid 1 Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0304-3B	10-X623	Citric Acid Discharge Valve to CIP Skid 2 Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0304-3B	10-X623	Citric Acid Discharge Valve to CIP Skid 2 Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0310-1A	10-X624	Sodium Hypochlorite Metering Pump 1 Air Intake Valve Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0310-1A	10-X624	Sodium Hypochlorite Metering Pump 1 Air Intake Valve Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZD-0310-2A	10-X624	Sodium Hypochlorite Metering Pump 2 Air Intake Valve Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0310-2A	10-X624	Sodium Hypochlorite Metering Pump 2 Air Intake Valve Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZB-0310-3A	10-X624	Sodium Hypochlorite Discharge Valve to CIP Skid 1 Command Close	MCP-0200-1	ETH	By Vendor	
P25-ZD-0310-3A	10-X624	Sodium Hypochlorite Discharge Valve to CIP Skid 1 Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZD-0310-3B	10-X624	Sodium Hypochlorite Discharge Valve to CIP Skid 2 Command Open	MCP-0200-1	ETH	By Vendor	
P25-ZB-0310-3B	10-X624	Sodium Hypochlorite Discharge Valve to CIP Skid 2 Command Close	MCP-0200-1	ETH	By Vendor	
P25-SI-0241-1	10-X625	UF Backwash Pump 1 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0241-2	10-X625	UF Backwash Pump 2 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-SI-0241-3	10-X625	UF Backwash Pump 3 Speed Indication	RIO-0000-1	AI	0 - 100%	
P25-LI-0241-6A	10-X625	Backwash Supply Cell 1 Level	PLC-0000-1	AI	0 - 15 FT	
P25-LI-0241-6B	10-X625	Backwash Supply Cell 2 Level	PLC-0000-1	AI	0 - 15 FT	
P25-SC-0241-1	10-X625	UF Backwash Pump 1 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0241-2	10-X625	UF Backwash Pump 2 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-SC-0241-3	10-X625	UF Backwash Pump 3 Speed Command	RIO-0000-1	AO	0 - 100%	
P25-MY-0241-1	10-X625	UF Backwash Pump 1 Emergency Stop	RIO-0000-1	DI	Bool	
P25-LAH-0240-1	10-X625	Backwash Supply Cell 1 Level Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0241-1	10-X625	UF Backwash Pump 1 In Remote	RIO-0000-1	DI	Bool	
P25-MN-0241-1	10-X625	UF Backwash Pump 1 Running	RIO-0000-1	DI	Bool	
P25-PAL-0241-1	10-X625	UF Backwash Pump 1 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-XF-0241-1	10-X625	UF Backwash Pump 1 VFD Fault	RIO-0000-1	DI	Bool	
P25-ZH-0240-1A	10-X625	Backwash Supply Cell Influent Valve 1 Open	PLC-0000-1	DI	Bool	
P25-ZF-0240-1A	10-X625	Backwash Supply Cell Influent Valve 1 Fault	PLC-0000-1	DI	Bool	
P25-ZL-0240-1A	10-X625	Backwash Supply Cell Influent Valve 1 Close	PLC-0000-1	DI	Bool	
P25-IR-0240-1A	10-X625	Backwash Supply Cell Influent Valve 1 In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0240-1B	10-X625	Backwash Supply Cell 1 Influent Valve 2 Closed	PLC-0000-1	DI	Bool	
P25-IR-0240-1B	10-X625	Backwash Supply Cell 1 Influent Valve 2 In Remote	PLC-0000-1	DI	Bool	
P25-ZF-0240-1B	10-X625	Backwash Supply Cell 1 Influent Valve 2 Fault	PLC-0000-1	DI	Bool	
P25-ZH-0240-1B	10-X625	Backwash Supply Cell 1 Influent Valve 2 Open	PLC-0000-1	DI	Bool	
P25-LAH-0240-2	10-X625	Backwash Supply Cell 2 Level Alarm High	PLC-0000-1	DI	Bool	
P25-IR-0241-2	10-X625	UF Backwash Pump 2 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0241-2	10-X625	UF Backwash Pump 2 Emergency Stop	RIO-0000-1	DI	Bool	
P25-PAL-0241-2	10-X625	UF Backwash Pump 2 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	

P25-MN-0241-2	10-X625	UF Backwash Pump 2 Running	RIO-0000-1	DI	Bool	
P25-XF-0241-2	10-X625	UF Backwash Pump 2 VFD Fault	RIO-0000-1	DI	Bool	
P25-ZF-0240-2A	10-X625	Backwash Supply Cell 2 Influent Valve 1 Fault	PLC-0000-1	DI	Bool	
P25-ZL-0240-2A	10-X625	Backwash Supply Cell 2 Influent Valve 1 Close	PLC-0000-1	DI	Bool	
P25-IR-0240-2A	10-X625	Backwash Supply Cell 2 Influent Valve 1 In Remote	PLC-0000-1	DI	Bool	
P25-ZH-0240-2A	10-X625	Backwash Supply Cell 2 Influent Valve 1 Open	PLC-0000-1	DI	Bool	
P25-IR-0240-2B	10-X625	Backwash Supply Cell 2 Influent Valve 2 In Remote	PLC-0000-1	DI	Bool	
P25-ZL-0240-2B	10-X625	Backwash Supply Cell 2 Influent Valve 2 Closed	PLC-0000-1	DI	Bool	
P25-ZF-0240-2B	10-X625	Backwash Supply Cell 2 Influent Valve 2 Fault	PLC-0000-1	DI	Bool	
P25-ZH-0240-2B	10-X625	Backwash Supply Cell 2 Influent Valve 2 Open	PLC-0000-1	DI	Bool	
P25-IR-0241-3	10-X625	UF Backwash Pump 3 In Remote	RIO-0000-1	DI	Bool	
P25-MY-0241-3	10-X625	UF Backwash Pump 3 Emergency Stop	RIO-0000-1	DI	Bool	
P25-XF-0241-3	10-X625	UF Backwash Pump 3 VFD Fault	RIO-0000-1	DI	Bool	
P25-PAL-0241-3	10-X625	UF Backwash Pump 3 Suction Pressure Alarm Low	PLC-0000-1	DI	Bool	
P25-MN-0241-3	10-X625	UF Backwash Pump 3 Running	RIO-0000-1	DI	Bool	
P25-MD-0241-1	10-X625	UF Backwash Pump 1 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZD-0240-1A	10-X625	Backwash Supply Cell Influent Valve 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0240-1A	10-X625	Backwash Supply Cell Influent Valve 1 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0240-1B	10-X625	Backwash Supply Cell 1 Influent Valve 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0240-1B	10-X625	Backwash Supply Cell 1 Influent Valve 2 Command Close	PLC-0000-1	DO	1 = Close	
P25-MD-0241-2	10-X625	UF Backwash Pump 2 Command Start	RIO-0000-1	DO	1 = Start	
P25-ZD-0240-2A	10-X625	Backwash Supply Cell 2 Influent Valve 1 Command Open	PLC-0000-1	DO	1 = Open	
P25-ZB-0240-2A	10-X625	Backwash Supply Cell 2 Influent Valve 1 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZB-0240-2B	10-X625	Backwash Supply Cell 2 Influent Valve 2 Command Close	PLC-0000-1	DO	1 = Close	
P25-ZD-0240-2B	10-X625	Backwash Supply Cell 2 Influent Valve 2 Command Open	PLC-0000-1	DO	1 = Open	
P25-MD-0241-3	10-X625	UF Backwash Pump 3 Command Start	RIO-0000-1	DO	1 = Start	
P25-PAL-0307-1	10-X626	Nitrogen Storage Tank Pressure Alarm Low	MCP-0305-1	ETH	By Vendor	
P25-PAH-0307-1	10-X626	Nitrogen Storage Tank Pressure Alarm High	MCP-0305-1	ETH	By Vendor	
P25-PI-0305-1	10-X626	LOX Storage Tank Pressure	MCP-0305-1	ETH	By Vendor	
P25-LI-0305-1	10-X626	LOX Storage Tank Level	MCP-0305-1	ETH	By Vendor	
P25-PI-0306-1B	10-X626	GOX Regulating Manifold Filter Suction Pressure	MCP-0305-1	ETH	By Vendor	
P25-DPAH-0307-2A	10-X626	Nitrogen Boost Compressor System Skid Filter 1 Differential Pressure Alarm High	MCP-0305-1	ETH	By Vendor	
P25-DPAH-0307-2B	10-X626	Nitrogen Boost Compressor System Skid Filter 2 Differential Pressure Alarm High	MCP-0305-1	ETH	By Vendor	
P25-DPAH-0307-2C	10-X626	Nitrogen Boost Compressor System Skid Filter 3 Differential Pressure Alarm High	MCP-0305-1	ETH	By Vendor	
P25-PI-0306-3A	10-X626	GOX Regulating Manifold Discharge Pressure	MCP-0305-1	ETH	By Vendor	
P25-TI-0306-3A	10-X626	GOX Regulating Manifold Discharge Temperature	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-1	10-X627	Ozone Generator 1 GOX Inlet Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-1	10-X627	Ozone Generator 1 GOX Inlet Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-YA-0308-1	10-X627	Ozone Generator 1 Fault	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-1	10-X627	Ozone Generator 1 GOX Inlet Valve Open	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-1A	10-X627	Ozone Generator 1 Ozone Discharge Valve Open	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-1A	10-X627	Ozone Generator 1 Ozone Discharge Valve Close	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-1A	10-X627	Ozone Generator 1 Ozone Discharge Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-1B	10-X627	Ozone Generator 1 Cooling Water Supply Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-1B	10-X627	Ozone Generator 1 Cooling Water Supply Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-1B	10-X627	Ozone Generator 1 Cooling Water Supply Valve Open	MCP-0305-1	ETH	By Vendor	
P25-FI-0308-1	10-X627	Ozone Generator 1 GOX Inlet Flow	MCP-0305-1	ETH	By Vendor	
P25-PAL-0308-1	10-X627	Ozone Generator 1 GOX Inlet Pressure Alarm Low	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-1	10-X627	Ozone Generator 1 Cooling Water Inlet Temperature	MCP-0305-1	ETH	By Vendor	

P25-TI-0308-1A	10-X627	Ozone Generator 1 Cooling Water Outlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-2	10-X627	Ozone Generator 2 GOX Inlet Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-2	10-X627	Ozone Generator 2 GOX Inlet Valve Open	MCP-0305-1	ETH	By Vendor	
P25-YA-0308-2	10-X627	Ozone Generator 2 Fault	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-2	10-X627	Ozone Generator 2 GOX Inlet Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-2A	10-X627	Ozone Generator 2 Ozone Discharge Valve Open	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-2A	10-X627	Ozone Generator 2 Ozone Discharge Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-2A	10-X627	Ozone Generator 2 Ozone Discharge Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-2B	10-X627	Ozone Generator 2 Cooling Water Supply Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-2B	10-X627	Ozone Generator 2 Cooling Water Supply Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-2B	10-X627	Ozone Generator 2 Cooling Water Supply Valve Open	MCP-0305-1	ETH	By Vendor	
P25-FI-0308-2	10-X627	Ozone Generator 2 GOX Inlet Flow	MCP-0305-1	ETH	By Vendor	
P25-PAL-0308-2	10-X627	Ozone Generator 2 GOX Inlet Pressure Alarm Low	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-2	10-X627	Ozone Generator 2 Cooling Water Inlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-2A	10-X627	Ozone Generator 2 Cooling Water Outlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-3	10-X627	Ozone Generator 3 GOX Inlet Valve Open	MCP-0305-1	ETH	By Vendor	
P25-YA-0308-3	10-X627	Ozone Generator 3 Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-3	10-X627	Ozone Generator 3 GOX Inlet Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-3	10-X627	Ozone Generator 3 GOX Inlet Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-3A	10-X627	Ozone Generator 3 Ozone Discharge Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-3A	10-X627	Ozone Generator 3 Ozone Discharge Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-3A	10-X627	Ozone Generator 3 Ozone Discharge Valve Open	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-3B	10-X627	Ozone Generator 3 Cooling Water Supply Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-3B	10-X627	Ozone Generator 3 Cooling Water Supply Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-3B	10-X627	Ozone Generator 3 Cooling Water Supply Valve Open	MCP-0305-1	ETH	By Vendor	
P25-FI-0308-3	10-X627	Ozone Generator 3 GOX Inlet Flow	MCP-0305-1	ETH	By Vendor	
P25-PAL-0308-3	10-X627	Ozone Generator 3 GOX Inlet Pressure Alarm Low	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-3	10-X627	Ozone Generator 3 Cooling Water Inlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-3A	10-X627	Ozone Generator 3 Cooling Water Outlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-4	10-X627	Ozone Generator 4 GOX Inlet Valve Open	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-4	10-X627	Ozone Generator 4 GOX Inlet Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-YA-0308-4	10-X627	Ozone Generator 4 Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-4	10-X627	Ozone Generator 4 GOX Inlet Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-4A	10-X627	Ozone Generator 4 Ozone Discharge Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-4A	10-X627	Ozone Generator 4 Ozone Discharge Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-4A	10-X627	Ozone Generator 4 Ozone Discharge Valve Open	MCP-0305-1	ETH	By Vendor	
P25-ZF-0308-4B	10-X627	Ozone Generator Cooling Water Supply Valve Fault	MCP-0305-1	ETH	By Vendor	
P25-ZL-0308-4B	10-X627	Ozone Generator Cooling Water Supply Valve Closed	MCP-0305-1	ETH	By Vendor	
P25-ZH-0308-4B	10-X627	Ozone Generator Cooling Water Supply Valve Open	MCP-0305-1	ETH	By Vendor	
P25-FI-0308-4	10-X627	Ozone Generator 4 GOX Inlet Flow	MCP-0305-1	ETH	By Vendor	
P25-PAL-0308-4	10-X627	Ozone Generator 4 GOX Inlet Pressure Alarm Low	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-4	10-X627	Ozone Generator 4 Cooling Water Inlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-TI-0308-4A	10-X627	Ozone Generator 4 Cooling Water Outlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-MN-0309-1	10-X627	Ozone Chiller 1 Running	MCP-0305-1	ETH	By Vendor	
P25-TI-0309-1A	10-X627	Ozone Chiller 1 Inlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-TI-0309-1B	10-X627	Ozone Chiller 1 Outlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-MN-0309-2	10-X627	Ozone Chiller 2 Running	MCP-0305-1	ETH	By Vendor	
P25-TI-0309-2A	10-X627	Ozone Chiller 2 Inlet Temperature	MCP-0305-1	ETH	By Vendor	
P25-TI-0309-2B	10-X627	Ozone Chiller 2 Outlet Temperature	MCP-0305-1	ETH	By Vendor	

P25-XC-0308-5	10-X627	Ozone System Command Start	MCP-0305-1	ETH	By Vendor	
P25-XA-0308-5	10-X627	Ozone System Alarm	MCP-0305-1	ETH	By Vendor	
P25-AAHH-0305-5A	10-X627	Ozone Room Ozone Content Alarm	MCP-0305-1	ETH	By Vendor	
P25-AAH-0305-5A	10-X627	Ozone Room Ozone Content Warning	MCP-0305-1	ETH	By Vendor	
P25-AAHH-0308-5B	10-X627	Ozone Room Oxygen Content Alarm	MCP-0305-1	ETH	By Vendor	
P25-AAH-0308-5B	10-X627	Ozone Room Oxygen Content Warning	MCP-0305-1	ETH	By Vendor	
P25-AI-0204-13A	10-X628	UF Filtrate Turbidity	PLC-0000-1	AI	0 - 100.0 NTU	
P25-AI-0204-13B	10-X628	UF Filtrate Total Suspended Solids	PLC-0000-1	AI	0 - 100	
P25-AI-0401-1A	10-X628	Sample Pump 1 Discharge Ozone Content	PLC-0000-1	AI	0 - 5 ppm	
P25-AI-0402-1A	10-X628	Sample Pump 3 Discharge Ozone Content	PLC-0000-1	AI	0 - 5 ppm	
P25-AI-0402-1B	10-X628	Sample Pump 4 Discharge Ozone Content	PLC-0000-1	AI	0 - 5 ppm	
P25-AI-0401-1B	10-X628	Sample Pump 2 Discharge Ozone Content	PLC-0000-1	AI	0 - 5 ppm	
P25-MY-0401-4	10-X628	Sample Pump 1 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MN-0401-4	10-X628	Sample Pump 1 Running	PLC-0000-1	DI	Bool	
P25-MY-0402-4	10-X628	Sample Pump 3 Emergency Stop	PLC-0000-1	DI	Bool	
P25-IR-0401-4	10-X628	Sample Pump 1 In Remote	PLC-0000-1	DI	Bool	
P25-MO-0402-4	10-X628	Sample Pump 3 Overload	PLC-0000-1	DI	Bool	
P25-MO-0401-4	10-X628	Sample Pump 1 Overload	PLC-0000-1	DI	Bool	
P25-IR-0402-4	10-X628	Sample Pump 3 In Remote	PLC-0000-1	DI	Bool	
P25-MN-0402-4	10-X628	Sample Pump 3 Running	PLC-0000-1	DI	Bool	
P25-MN-0401-5	10-X628	Sample Pump 2 Running	PLC-0000-1	DI	Bool	
P25-MY-0401-5	10-X628	Sample Pump 2 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MO-0402-5	10-X628	Sample Pump 4 Overload	PLC-0000-1	DI	Bool	
P25-IR-0402-5	10-X628	Sample Pump 4 In Remote	PLC-0000-1	DI	Bool	
P25-MN-0402-5	10-X628	Sample Pump 4 Running	PLC-0000-1	DI	Bool	
P25-IR-0401-5	10-X628	Sample Pump 2 In Remote	PLC-0000-1	DI	Bool	
P25-MY-0402-5	10-X628	Sample Pump 4 Emergency Stop	PLC-0000-1	DI	Bool	
P25-MO-0401-5	10-X628	Sample Pump 2 Overload	PLC-0000-1	DI	Bool	
P25-MD-0401-4	10-X628	Sample Pump 1 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0402-4	10-X628	Sample Pump 3 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0401-5	10-X628	Sample Pump 2 Command Start	PLC-0000-1	DO	1 = Start	
P25-MD-0402-5	10-X628	Sample Pump 4 Command Start	PLC-0000-1	DO	1 = Start	
P25-LAH-0308-5	10-X628	Ozone Injection Pump Skid Ozone Tank Level Alarm High	MCP-0305-1	ETH	Vendor	
P25-FI-0308-5	10-X628	Ozone Injection Pump Skid Ozone Inlet Flow	MCP-0305-1	ETH	Vendor	
P25-ZH-0308-5A	10-X628	Ozone Injection Pump Skid Ozone Inlet Valve Open	MCP-0305-1	ETH	Vendor	
P25-ZF-0308-5A	10-X628	Ozone Injection Pump Skid Ozone Inlet Valve Fault	MCP-0305-1	ETH	Vendor	
P25-ZL-0308-5A	10-X628	Ozone Injection Pump Skid Ozone Inlet Valve Closed	MCP-0305-1	ETH	Vendor	
P25-ZL-0308-5B	10-X628	Ozone Injection Pump Skid Ozone Tank Discharge Valve Closed	MCP-0305-1	ETH	Vendor	
P25-ZF-0308-5B	10-X628	Ozone Injection Pump Skid Ozone Tank Discharge Valve Fault	MCP-0305-1	ETH	Vendor	
P25-ZH-0308-5B	10-X628	Ozone Injection Pump Skid Ozone Tank Discharge Valve Open	MCP-0305-1	ETH	Vendor	
P25-PAH-0308-6B	10-X628	Ozone Injection Pump 1 Discharge Pressure Alarm High	MCP-0305-1	ETH	Vendor	
P25-PAH-0308-7B	10-X628	Ozone Injection Pump 2 Discharge Pressure Alarm High	MCP-0305-1	ETH	Vendor	
P25-MO-0308-6	10-X628	Ozone Injection Pump 1 Overload	MCP-0305-1	ETH	Vendor	
P25-MN-0308-6	10-X628	Ozone Injection Pump 1 Running	MCP-0305-1	ETH	Vendor	
P25-MY-0308-6	10-X628	Ozone Injection Pump 1 Emergency Stop	MCP-0305-1	ETH	Vendor	
P25-SI-0308-6	10-X628	Ozone Injection Pump 1 Speed Indication	MCP-0305-1	ETH	Vendor	
P25-SC-0308-6	10-X628	Ozone Injection Pump 1 Speed Command	MCP-0305-1	ETH	Vendor	
P25-IR-0308-6	10-X628	Ozone Injection Pump 1 In Remote	MCP-0305-1	ETH	Vendor	
P25-XF-0308-6	10-X628	Ozone Injection Pump 1 VFD Fault	MCP-0305-1	ETH	Vendor	

P25-MD-0308-6	10-X628	Ozone Injection Pump 1 Command Start	MCP-0305-1	ETH	Vendor	
P25-FI-0308-6A	10-X628	Ozone Injection Pump Skid Motive Water Inlet Flow	MCP-0305-1	ETH	Vendor	
P25-PI-0308-6A	10-X628	Ozone Injection Skid Motive Water Pressure	MCP-0305-1	ETH	Vendor	
P25-SC-0308-7	10-X628	Ozone Injection Pump 2 Speed Command	MCP-0305-1	ETH	Vendor	
P25-IR-0308-7	10-X628	Ozone Injection Pump 2 In Remote	MCP-0305-1	ETH	Vendor	
P25-XF-0308-7	10-X628	Ozone Injection Pump 2 VFD Fault	MCP-0305-1	ETH	Vendor	
P25-MD-0308-7	10-X628	Ozone Injection Pump 2 Command Start	MCP-0305-1	ETH	Vendor	
P25-MN-0308-7	10-X628	Ozone Injection Pump 2 Running	MCP-0305-1	ETH	Vendor	
P25-MY-0308-7	10-X628	Ozone Injection Pump 2 Emergency Stop	MCP-0305-1	ETH	Vendor	
P25-MO-0308-7	10-X628	Ozone Injection Pump 2 Overload	MCP-0305-1	ETH	Vendor	
P25-SI-0308-7	10-X628	Ozone Injection Pump 2 Speed Indication	MCP-0305-1	ETH	Vendor	
P25-LI-0402-1	20-X601	West Clearwell Ozone Contact Basin Level	PLC-0000-2	AI	0 - 25 FT	
P25-AI-0403-1	20-X601	Finished Water Chlorine	PLC-0000-2	AI	0 - 10 ppm	
P25-LI-0401-1	20-X601	East Clearwell Ozone Contact Basin Level	PLC-0000-2	AI	0 - 25 FT	
P25-PI-0403-1A	20-X601	West Clearwell Drain Line Pressure	PLC-0000-2	AI	0 - 30 PSI	
P25-PI-0403-1B	20-X601	East Clearwell Drain Line Pressure	PLC-0000-2	AI	0 - 30 PSI	
P25-ZIO-0403-2	20-X601	Clearwell Drain Vault Hatch Intrusion Switch Position Open	PLC-0000-2	DI	Bool	
P25-ZIO-0401-1?	20-X601	East Clearwell Hatch Intrusion Switch Position Open	PLC-0000-2	DI	Bool	
P25-LAHH-0403-1	20-X601	Drain Vault Sump Level Alarm High High	PLC-0000-2	DI	Bool	
P25-ZIO-0402-1	20-X601	West Clearwell Hatch Intrusion Switch Position Open	PLC-0000-2	DI	Bool	
P25-LAH-0401-1	20-X601	Clearwell Emergency Overflow Trough Level Alarm High	PLC-0000-2	DI	Bool	
P25-PI-0417-1	20-X602	High Service Pump Station Discharge Header Pressure	PLC-0000-2	AI	0 - 200 PSI	
P25-SI-0413-1	20-X602	High Service Pump 3 Speed Indication	PLC-0000-2	AI	0 - 100%	
P25-SI-0411-1	20-X602	High Service Pump 1 Speed Indication	PLC-0000-2	AI	0 - 100%	
P25-FI-0417-1	20-X602	High Service Pump Station Discharge Header Flow	PLC-0000-2	AI	0 - 21,000 GPM	
P25-SI-0412-1	20-X602	High Service Pump 2 Speed Indication	PLC-0000-2	AI	0 - 100%	
P25-SI-0415-1	20-X602	High Service Pump 5 Speed Indication	PLC-0000-2	AI	0 - 100%	
P25-SI-0414-1	20-X602	High Service Pump 4 Speed Indication	PLC-0000-2	AI	0 - 100%	
P25-TI-0418-1A	20-X602	High Service Pump Station Discharge Sample Temperature	PLC-0000-2	AI	36 - 80 Deg F	
P25-AI-0418-1B	20-X602	High Service Pump Station Discharge Sample pH	PLC-0000-2	AI	0 - 14.0	
P25-DPI-0417-1	20-X602	Surge Bladder 1 Differential Pressure	PLC-0000-2	AI	-250 - 250 inH2O	Surge Bladder Level
P25-DPI-0417-2	20-X602	Surge Bladder 2 Differential Pressure	PLC-0000-2	AI	-250 - 250 inH2O	Surge Bladder Level
P25-SC-0415-1	20-X602	High Service Pump 5 Speed Command	PLC-0000-2	AO	0 - 100%	
P25-SC-0412-1	20-X602	High Service Pump 2 Speed Command	PLC-0000-2	AO	0 - 100%	
P25-SC-0414-1	20-X602	High Service Pump 4 Speed Command	PLC-0000-2	AO	0 - 100%	
P25-SC-0413-1	20-X602	High Service Pump 3 Speed Command	PLC-0000-2	AO	0 - 100%	
P25-SC-0411-1	20-X602	High Service Pump 1 Speed Command	PLC-0000-2	AO	0 - 100%	
P25-MN-0412-1	20-X602	High Service Pump 2 Running	PLC-0000-2	DI	Bool	
P25-MN-0415-1	20-X602	High Service Pump 5 Running	PLC-0000-2	DI	Bool	
P25-ZIC-0415-1	20-X602	High Service Pump 5 Discharge Valve Closed	PLC-0000-2	DI	Bool	
P25-XF-0414-1	20-X602	High Service Pump 4 VFD Fault	PLC-0000-2	DI	Bool	
P25-XF-0415-1	20-X602	High Service Pump 5 VFD Fault	PLC-0000-2	DI	Bool	
P25-IR-0412-1	20-X602	High Service Pump 2 In Remote	PLC-0000-2	DI	Bool	
P25-ZIO-0414-1	20-X602	High Service Pump 4 Discharge Valve Open	PLC-0000-2	DI	Bool	
P25-ZIO-0411-1	20-X602	High Service Pump 1 Discharge Valve Open	PLC-0000-2	DI	Bool	
P25-MN-0414-1	20-X602	High Service Pump 4 Running	PLC-0000-2	DI	Bool	
P25-MY-0412-1	20-X602	High Service Pump 2 Emergency Stop	PLC-0000-2	DI	Bool	
P25-PAH-0414-1	20-X602	High Service Pump 4 Discharge Valve Fail	PLC-0000-2	DI	Bool	
P25-ZIO-0412-1	20-X602	High Service Pump 2 Discharge Valve Open	PLC-0000-2	DI	Bool	

P25-XA-0414-1	20-X602	High Service Pump 4 Motor Protection Relay Alarm	PLC-0000-2	DI	Bool	
P25-IR-0414-1	20-X602	High Service Pump 4 In Remote	PLC-0000-2	DI	Bool	
P25-IR-0415-1	20-X602	High Service Pump 5 In Remote	PLC-0000-2	DI	Bool	
P25-XF-0413-1	20-X602	High Service Pump 3 VFD Fault	PLC-0000-2	DI	Bool	
P25-XA-0411-1	20-X602	High Service Pump 1 Motor Protection Relay Alarm	PLC-0000-2	DI	Bool	
P25-XA-0411-2	20-X602	High Service Pump 1 Vibration Alarm	PLC-0000-2	DI	Bool	
P25-XF-0412-1	20-X602	High Service Pump 2 VFD Fault	PLC-0000-2	DI	Bool	
P25-IR-0413-1	20-X602	High Service Pump 3 In Remote	PLC-0000-2	DI	Bool	
P25-IR-0411-1	20-X602	High Service Pump 1 In Remote	PLC-0000-2	DI	Bool	
P25-XF-0411-1	20-X602	High Service Pump 1 VFD Fault	PLC-0000-2	DI	Bool	
P25-ZIO-0413-1	20-X602	High Service Pump 3 Discharge Valve Open	PLC-0000-2	DI	Bool	
P25-XA-0412-1	20-X602	High Service Pump 2 Motor Protection Relay Alarm	PLC-0000-2	DI	Bool	
P25-XA-0412-2	20-X602	High Service Pump 2 Vibration Alarm	PLC-0000-2	DI	Bool	
P25-MY-0413-1	20-X602	High Service Pump 3 Emergency Stop	PLC-0000-2	DI	Bool	
P25-XA-0413-1	20-X602	High Service Pump 3 Motor Protection Relay Alarm	PLC-0000-2	DI	Bool	
P25-XA-0413-2	20-X602	High Service Pump 3 Vibration Alarm	PLC-0000-2	DI	Bool	
P25-PAH-0412-1	20-X602	High Service Pump 2 Discharge Valve Fail	PLC-0000-2	DI	Bool	
P25-ZIC-0413-1	20-X602	High Service Pump 3 Discharge Valve Closed	PLC-0000-2	DI	Bool	
P25-ZIO-0415-1	20-X602	High Service Pump 5 Discharge Valve Open	PLC-0000-2	DI	Bool	
P25-ZIC-0412-1	20-X602	High Service Pump 2 Discharge Valve Closed	PLC-0000-2	DI	Bool	
P25-ZF-0415-1	20-X602	High Service Pump 5 Discharge Valve Fail	PLC-0000-2	DI	Bool	
P25-PAH-0413-1	20-X602	High Service Pump 3 Discharge Valve Fail	PLC-0000-2	DI	Bool	
P25-MY-0411-1	20-X602	High Service Pump 1 Emergency Stop	PLC-0000-2	DI	Bool	
P25-ZIC-0411-1	20-X602	High Service Pump 1 Discharge Valve Closed	PLC-0000-2	DI	Bool	
P25-PAL-0416-1	20-X602	High Service Pump Station Suction Header Pressure Alarm Low	PLC-0000-2	DI	Bool	
P25-MY-0414-1	20-X602	High Service Pump 4 Emergency Stop	PLC-0000-2	DI	Bool	
P25-PAH-0411-1	20-X602	High Service Pump 1 Discharge Valve Fail	PLC-0000-2	DI	Bool	
P25-XA-0415-1	20-X602	High Service Pump 5 Motor Protection Relay Alarm	PLC-0000-2	DI	Bool	
P25-XA-0415-2	20-X602	High Service Pump 5 Vibration Alarm	PLC-0000-2	DI	Bool	
P25-MN-0413-1	20-X602	High Service Pump 3 Running	PLC-0000-2	DI	Bool	
P25-LAHH-0410-1	20-X602	High Service Pump Station Sump Level Alarm High High	PLC-0000-2	DI	Bool	
P25-MY-0415-1	20-X602	High Service Pump 5 Emergency Stop	PLC-0000-2	DI	Bool	
P25-MN-0411-1	20-X602	High Service Pump 1 Running	PLC-0000-2	DI	Bool	
P25-ZIC-0414-1	20-X602	High Service Pump 4 Discharge Valve Closed	PLC-0000-2	DI	Bool	
P25-XA-0414-2	20-X602	High Service Pump 4 Vibration Alarm	PLC-0000-2	DI	Bool	
P25-FAL-0417-1	20-X602	High Service Pump Station Discharge Header Flow Alarm Low	PLC-0000-2	DI	Bool	
P25-MD-0414-1	20-X602	High Service Pump 4 Command Start	PLC-0000-2	DO	1 = Start	
P25-MD-0413-1	20-X602	High Service Pump 3 Command Start	PLC-0000-2	DO	1 = Start	
P25-MD-0415-1	20-X602	High Service Pump 5 Command Start	PLC-0000-2	DO	1 = Start	
P25-MD-0412-1	20-X602	High Service Pump 2 Command Start	PLC-0000-2	DO	1 = Start	
P25-MD-0411-1	20-X602	High Service Pump 1 Command Start	PLC-0000-2	DO	1 = Start	
P25-ZB-0418-1	20-X602	High Service Pump Station Discharge Header Sample Valve Command Close	PLC-0000-2	DO	1 = Close	
P25-ZD-0418-1	20-X602	High Service Pump Station Discharge Header Sample Valve Command Open	PLC-0000-2	DO	1 = Open	
P25-PI-0401-1	20-X603	Ozone Demister 1 Suction Pressure	PLC-0000-2	AI	By Vendor	Confirm range with Ozone System Vendor
P25-PI-0402-1	20-X603	Ozone Demister 2 Suction Pressure	PLC-0000-2	AI	By Vendor	Confirm range with Ozone System Vendor
P25-DPAH-0402-1	20-X603	Ozone Demister 2 Differential Pressure Alarm High	PLC-0000-2	DI	By Vendor	
P25-DPAH-0401-1	20-X603	Ozone Demister 1 Differential Pressure Alarm High	PLC-0000-2	DI	By Vendor	
P25-LAHH-0419-1	30-X601	Transmission Valve Vault Level Alarm High High	PLC-0000-2	DI	Bool	
P25-ZIO-0419-1	30-X601	Transmission Valve Vault Hatch Position Open	PLC-0000-2	DI	Bool	

SECTION 40 61 96

PROCESS CONTROL DESCRIPTIONS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide control system programming and configuration services to achieve the operational functionality generally as described in the control descriptions provided in this section and in compliance with the P&IDs and other Contract Documents.
 - 1. This Section outlines the proposed operation and control strategies for the proposed equipment for the Provo River Water Treatment Plant.
 - 2. It should be noted that these control descriptions are provided as a guide to the intent of the main control strategies and do not purport to describe every detail and nuance of the completed programs. The I&C Subcontractor and Contractor must study contract documents and take into consideration the Provo City Water Resources standard practices for PLC program design, graphics objects characteristics, screen layouts, and operator interface features as detailed in subsequent sections.
 - 3. All aspects of the new control sequences, operator interface, and remote monitoring must be thoroughly tested in cooperation with the Owner and the Engineer to demonstrate correct functioning of all control system features and to verify that all interlocks and alarms are functioning properly.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging
 - 2. S5.4: Instrument Loop Diagrams
 - 3. S7: Instrument Air
 - 4. S12: Electrical Equipment for Hazardous Locations
 - 5. S18.2: Alarm Management
 - 6. S20: Instrument Specifications
 - 7. S50: Electrical Control Signals
 - 8. S75: Control Valve Design, Specification and Testing
 - 9. S96: Valve Actuators

10. S99: Control System Cyber Security

11. 101: Human-Machine Interfaces

1.03 QUALITY ASSURANCE

A. Comply with the requirements specified in Section 01 43 00.

PART 2 PROCESS CONTROL DESCRIPTIONS

2.01 RIVER INTAKE

A. Loop 0101 Raw Water Diversion Wet Well

1. P25-SCR-0101-1 Intake Screen Brush Cleaning System

- a. The operator may select between local operation of the screen in the field or remote operation by the SCADA system.
- b. When in remote operation by the SCADA system, the screen operates on a differential level calculated by upstream and downstream level indicating transmitters P25-LIT-0101-1A (upstream) and P25-LIT-0101-1B (downstream).
- c. Hydraulic motor running and motor overload are monitored and displayed.
- d. Travel motor running and motor overload are monitored and displayed.

2. P25-PMP-0101-2 Intake Screen Washdown Pump

- a. The operator may select between local operation of the washdown system pump in the field or remote operation by the SCADA system. When in remote operation the pump shall operate on an operator-selectable timer, initially set at once every 24 hours.
- b. Upon operating the pump sends water from a 48" diameter manhole to the spray connection on the intake screen for washing sediment built-up in front of the screen.
- c. Pump motor running and motor overload are monitored and displayed.

3. P25-RDG-0101-3 Intake Screen Bypass Radial Gate

- a. The operator may select between local operation of the radial gate in the field or remote operation by the SCADA system.

- b. If needed, the operator may locally or remotely open or close the motor-actuated radial gate to adjust the diversion of raw water flow around the intake screen and back into the river.
 - c. Gate percentage open, fully open, and fully closed limit switches are displayed.
 - d. If the slide gate motor actuator fails, an alarm is generated.
- 4. P25-SDG-0101-1A Wet Well Effluent Slide Gate
 - a. The operator may select between local operation of the slide gate in the field or remote operation by the SCADA system.
 - b. If needed, the operator may locally or remotely open or close the motor-actuated slide gate to adjust the flow of raw water into the diversion box.
 - c. Gate percentage open, fully open, and fully closed limit switches are displayed.
 - d. If the slide gate motor actuator fails, an alarm is generated.
 - e. Effluent flow from the Raw Water Diversion Wet Well to the Diversion Box is measured by ultrasonic flow meter P25-FE/FIT-0101-1. The operator shall set a flow rate that is maintained by opening or closing the slide gate.
- 5. Raw Water Quality
 - a. Incoming raw water quality is analyzed in the raw water diversion wet well by two water quality analyzers P25-AIT-0101-1A and P25-AIT-0101-1B. P25-AIT-0101-1A, upstream of the intake screen, analyzes the raw water for BOD, COD, DOC, TOC, UV254, and NO3. P25-AIT-0101-1B, downstream of the intake screen inside the diversion wet well, analyzes turbidity. If turbidity reaches a high level, determined during start-up and commissioning, an alarm is generated.

2.02 PLANT INTAKE

A. Loop 0102 Diversion Box

1. Diversion Box Level

- a. Raw water level in the diversion box is measured by P25-LIT-0102-1. If the level in the box reaches an operator-defined maximum level, an alarm is generated. If the level in the box reaches an operator-defined minimum level, an alarm is generated and any UF Feed Pumps shall trip offline.

2. P25-SDG-0102-1A Diversion Box Slide Gate to In-Line Flash Reactor

- a. The operator may select between local operation of the slide gate in the field or remote operation by the SCADA system.
 - b. If needed, the operator may locally or remotely open or close the motor-actuated slide gate to adjust the flow of raw water into the water treatment plant in-line flash reactor.
 - c. Gate percentage open, fully open, and fully closed limit switches are displayed.
 - d. If the slide gate motor actuator fails, an alarm is generated. If there is a high turbidity alarm, this slide gate closes and gate P25-SDG-0102-1B opens.
- 3. P25-SDG-0102-1B Diversion Box Slide Gate to Mill Race Canal
 - a. The operator may select between local operation of the slide gate in the field or remote operation by the SCADA system.
 - b. If needed, the operator may locally or remotely open or close the motor-actuated slide gate to adjust the flow of raw water to the Mill Race Canal.
 - c. Gate percentage open, fully open, and fully closed limit switches are displayed.
 - d. If the slide gate motor actuator fails, an alarm is generated.
- 4. Irrigation Pump System
 - a. Raw water flow taken by the irrigation system is measured by electromagnetic flow meter P25-FE/FIT-0102-2.

2.03 RAW WATER PLANT INFLUENT

A. Loop 0303 Plant Water Influent

- 1. Raw Water Plant Influent Flow
 - a. Influent flow to the plant, downstream from the in-line flash reactor, is measured by an electromagnetic flow meter P25-FE/FIT-0303-1.
- 2. Raw Water Plant Influent Water Quality Analyzers
 - a. Influent raw water turbidity is measured by an analyzer P25-AIT-0303-1A. If the turbidity value exceeds an operator-defined limit for acceptable influent water quality, an alarm is generated.
 - b. Influent raw water pH is measured by an analyzer P25-AIT-0303-1B. If the pH value falls outside an operator-defined range for acceptable influent water quality, an alarm is generated.

3. Raw Water Influent Pressure

- a. Influent raw water pressure, downstream of the point of emergency chlorine solution injection, is measured by P25-PIT-0303-1.

2.04 ULTRAFILTRATION

A. Loop 0200 UF Skids Main Control Panel

- 1. The Ultrafiltration system will operate a set number of UF skids based on an operator setpoint. The operator will also select the lead, lag, lag-lag, etc. order of UF skids. The controlling setpoint for starting and stopping of skids is the level in the clear well cells.
- 2. P25-MCP-0200-1
 - a. The subsequent UF Skid and CIP Skid local vendor control panels are connected via Ethernet to a master vendor control panel. The following points at a minimum are monitored and displayed for each UF skid:
 - (1) Status of skid including production mode, backwash (and sequence of backwash step), maintenance clean, CIP, integrity test, standby, and offline.
 - (2) General UF Skid Alarm
 - (3) Feed pressure, filtrate pressure, and Transmembrane Pressure (TMP)
 - (4) Control valve positions
 - (5) Water temperature
 - (6) Normalized permeability
 - (7) Normalized membrane flux
 - (8) Air system pressure
 - (9) Filtrate Flow
 - (10) Filtrate Turbidity
 - b. The Manufacturer's MCP automatically controls:
 - (1) UF skids start-up
 - (2) sequencing of increasing or decreasing the number of operating UF skids

- (3) sequencing skid backwashing
- (4) sequencing membrane integrity testing
- (5) filter effluent output to maintain a clearwell level set point received from SCADA
- (6) UF skid clean-in-place systems and sequencing maintenance cleans

B. Loop 0201 UF Skid 1 (Typical of thirteen total UF Skids)

1. P25-PMP-0201-1

- a. UF Skid 1 is fed by a vertical turbine feed pump. The operator is able to assign the pump into and out of service as necessary.
- b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback are monitored for the feed pump. VFD fail generates an alarm.
- c. In automatic, the UF main control panel will request start and stop of the corresponding UF feed pump and adjust VFD speed based on the pressure required to maintain the membrane flux.
- d. The pump may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed will be maintained.
- e. If the pump local emergency stop is engaged, the pump will trip offline and an alarm will be generated.
- f. Suction pressure to the feed pump will be monitored by pressure switch P25-PSL-0201-1. If the pressure in the influent pipe drops below the acceptable limit for the feed pump, an alarm will be generated, and the pump will trip offline.

2. P25-STR-0201-2

- a. The discharge of UF Feed Pump 1 will be pumped through an electrically cleaned strainer.
- b. Strainer motor running, in remote, and overload will be monitored by the SCADA system.
- c. Differential pressure across the strainer will be measured by P25-DPSH-0201-2. When the setpoint of this differential pressure switch is reached, the

SCADA system will initiate a strainer backwash cycle consisting of the following:

- (1) Open BWW outlet valve
 - (2) Start strainer motor
 - (3) Run for time setpoint (adjustable from 10 to 120 seconds)
 - (4) Stop strainer motor
 - (5) Close BWW outlet valve
- d. When a high-high differential pressure setpoint value is reached, an alarm is generated in the SCADA system and a stop command is sent to UF skid 1.
 - e. The operator may start the strainer motor from the SCADA system while in remote. If the strainer motor is in local, the strainer cleaning motor may be started at the motor control center located in the electrical room.
 - f. Pressure may be locally viewed on the upstream and downstream side of the strainer by P25-PI-0201-2A and P25-PI-0201-2B, respectively.
3. P25-SK-0201-3 & P25-LCP-0201-3 UF Skid 1 Local Control Panel
 - a. UF Skid 1 will be equipped with a local vendor control panel to monitor and control the dedicated feed pump and UF skid including monitor and control of all pneumatic control valves, pressure transmitters, flow meters, temperature monitors, pH analyzers, turbidimeters, and all related skid-mounted instrumentation. Refer to specification Section 46 61 33 for additional details, requirements, and control descriptions.

2.05 ULTRAFILTRATION CLEAN-IN-PLACE SKIDS

A. Loop 0221 Clean-In-Place Skid 1

1. UF CIP Skid 1 will be equipped with a local vendor control panel to monitor and control the CIP Tank and Skid operation including control of the CIP pump and monitoring of tank water level, pH, temperature, chlorine residual, and status of UF skid receiving a clean. Refer to specification Section 46 61 33 for additional details, requirements, and control descriptions.
2. P25-LCP-0221-1 UF CIP Skid 1 Local Control Panel
 - a. The local vendor control panel will be connected via Ethernet to the UF Skid main vendor control panel P25-MCP-0200-1. The following points at a minimum will be monitored and displayed for the CIP skid:
 - (1) CIP Pump 1 run status

- (2) CIP Pump 1 VFD speed
- (3) CIP Pump 1 Alarm
- (4) CIP Tank 1 heater run status
- (5) CIP Tank 1 heater alarm
- (6) CIP Tank 1 pH
- (7) CIP Tank 1 free chlorine residual
- (8) CIP Tank 1 water temperature
- (9) CIP Tank 1 high temperature alarm
- (10) CIP Tank 1 water level
- (11) CIP Tank 1 high water level alarm

B. Loop 0222 Clean-in-Place Skid 2

- 1. UF CIP Skid 2 will be equipped with a local vendor control panel to monitor and control the CIP Tank and Skid, as well as monitor and control all pneumatic supply and control valves and all related skid-mounted instrumentation. Refer to specification Section 46 61 33 for additional details, requirements, and control descriptions.
- 2. P25-LCP-0222-1 UF CIP Skid 2 Local Control Panel
 - a. The local vendor control panel will be connected via Ethernet to the UF Skid main vendor control panel P25-MCP-0200-1. The following points at a minimum will be monitored and displayed for the CIP skid:
 - (1) CIP Pump 2 run status
 - (2) CIP Pump 2 VFD speed
 - (3) CIP Pump 2 Alarm
 - (4) CIP Tank 2 heater run status
 - (5) CIP Tank 2 heater alarm
 - (6) CIP Tank 2 pH
 - (7) CIP Tank 2 free chlorine residual
 - (8) CIP Tank 2 water temperature

- (9) CIP Tank 2 high temperature alarm
- (10) CIP Tank 2 water level
- (11) CIP Tank 2 high water level alarm

2.06 BACKWASH WASTE

A. Loop 0250 Backwash Waste Tank Cells

1. In automatic mode, the backwash waste tank will function in a rotational batch configuration utilizing level-based control. At any one time, one cell will be filling, one cell will be setting, and one cell will be decanting. While filling, the cell will have inlet valves open and outlet valves closed. While settling, all inlet and outlet valves associated with the cell are closed. While decanting, the cell outlet valves are open with corresponding recycle and sludge pumps running, as described in subsequent sections.
2. Backwash Waste Tank Cell 1 Influent Valves P25-FV-0250-1A through P25-FV-0250-1D
 - a. Backwash waste from the strainers, UF skids, and air purge lines from the UF skids are drained to the backwash tank.
 - b. The operator may select between local operation of the influent valves in the field or remote operation by the SCADA system.
 - c. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of backwash into the backwash tank cell.
 - d. Valve position fully open and fully closed limit switches will be displayed.
 - e. If a valve motor actuator fails, an alarm is generated.
3. Backwash Cell 1 Decanter P25-DEC-0250-1 and Effluent Valves P25-FV-0250-1E and P25-FV-0250-1F
 - a. Liquid effluent from the backwash tank cell passes through a floating decanter and a corresponding effluent valve is opened to permit flow of the backwash to the backwash recycle pumps.
 - b. Sludge effluent from the backwash tank cell collects at the bottom of the backwash tank cells and a corresponding effluent valve is opened to permit flow of the sludge to the backwash sludge pumps.
 - c. The operator may select between local operation of the effluent valves in the field or remote operation by the SCADA system.

- d. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of backwash effluent to the backwash recycle pumps or backwash sludge pumps.
 - e. Valve position fully open and fully closed limit switches are monitored and displayed.
 - f. If a valve motor actuator fails, an alarm is generated.
4. Backwash Tank Cell 1 Level
- a. Liquid level in the tank cell is measured by P25-LE-0250-1. If the level in the cell reaches an operator-defined maximum level, and alarm is generated.
 - b. If maximum level in the tank is reached during an active backwash cycle, as measured by P25-LSH-0250-1, backwash influent flow will be diverted to the next available cell in the backwash tank.
5. Backwash Cell 2 Influent Valves P25-FV-0250-2A through P25-FV-0250-2D
- a. Backwash waste from the UF feed pump skid strainers, UF skids, and UF CIP skids as well as air purge lines from the UF skids are drained to the backwash tank. When a backwash cycle is initiated by the operator, the corresponding valves are opened to permit influent of the backwash to the tank.
 - b. The operator may select between local operation of the influent valves in the field or remote operation by the SCADA system.
 - c. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of backwash into the backwash tank cell.
 - d. Valve position fully open and fully closed limit switches will be displayed.
 - e. If a valve motor actuator fails, an alarm is generated.
6. Backwash Cell 2 Decanter P25-DEC-0250-2 and Effluent Valves P25-FV-0250-2E and P25-FV-0250-2F
- a. Liquid effluent from the backwash tank cell passes through a floating decanter and a corresponding effluent valve is opened to permit flow of the backwash to the backwash recycle pumps.
 - b. Sludge effluent from the backwash tank cell collects at the bottom of the backwash tank cells and a corresponding effluent valve is opened to permit flow of the sludge to the backwash sludge pumps.
 - c. The operator may select between local operation of the effluent valves in the field or remote operation by the SCADA system.

- d. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of backwash effluent to the backwash recycle pumps or backwash sludge pumps.
 - e. Valve position fully open and fully closed limit switches are monitored and displayed.
 - f. If a valve motor actuator fails, an alarm is generated.
7. Backwash Tank Cell 2 Level
- a. Liquid level in the tank cell is measured by P25-LE-0250-2. If the level in the cell reaches an operator-defined maximum level, an alarm is generated.
 - b. If maximum level in the tank is reached during an active backwash cycle, as measured by P25-LSH-0250-2, backwash influent flow will be diverted to the next available cell in the backwash tank.
8. Backwash Cell 3 Influent Valves P25-FV-0250-3A through P25-FV-0250-3D
- a. Backwash waste from the UF feed pump skid strainers, UF skids, and UF CIP skids as well as air purge lines from the UF skids are drained to the backwash tank. When a backwash cycle is initiated by the operator, the corresponding valves are opened to permit influent of the backwash to the tank.
 - b. The operator may select between local operation of the influent valves in the field or remote operation by the SCADA system.
 - c. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of backwash into the backwash tank cell.
 - d. Valve position fully open and fully closed limit switches will be displayed.
 - e. If a valve motor actuator fails, an alarm is generated.
9. Backwash Cell 3 Decanter P25-DEC-0250-3 and Effluent Valve P25-FV-0250-3E and P25-FV-0250-3F
- a. Liquid effluent from the backwash tank cell passes through a floating decanter and a corresponding effluent valve is opened to permit flow of the backwash to the backwash recycle pumps.
 - b. Sludge effluent from the backwash tank cell collects at the bottom of the backwash tank cells and a corresponding effluent valve is opened to permit flow of the sludge to the backwash sludge pumps.
 - c. The operator may select between local operation of the effluent valves in the field or remote operation by the SCADA system.

- d. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of backwash effluent to the backwash recycle pumps.
 - e. Valve position fully open and fully closed limit switches are monitored and displayed.
 - f. If a valve motor actuator fails, an alarm is generated.
10. Backwash Tank Cell 3 Level
- a. Liquid level in the tank cell is measured by P25-LE-0250-3. If the level in the cell reaches an operator-defined maximum level, an alarm is generated.
 - b. If maximum level in the tank is reached during an active backwash cycle, as measured by P25-LSH-0250-3, backwash influent flow will be diverted to the next available cell in the backwash tank.

B. Loop 0251 Backwash Recycle Pumping

- 1. Liquid effluent through the backwash tank cell decanters flow to the backwash recycle pump header. Each backwash recycle pump sends water to the raw water influent pipe at the head of the plant. Backwash recycle shall not exceed 10% of total raw water plant influent, are measured by P25-FE/FIT-0251-1.
- 2. P25-PMP-0251-1, P25-PMP-0251-2, P25-PMP-0251-3, P25-PMP-0251-4
 - a. Each backwash recycle pump is equipped with a VFD. The operator can assign the pumps into and out of service as necessary.
 - b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for each pump. VFD fail generates an alarm.
 - c. In automatic, the SCADA system will start and stop the recycle pumps based on the level in the backwash tank cells and the required quantity of UF Skids required to maintain the high service pump station outlet pressure.
 - d. Each pump may be placed in remote manual mode at the VFD. In this mode, the operator may turn the pumps on or off and set the speed of the pump accordingly. If a pump is running and it is placed into or out of remote manual mode, the pump run status and running speed will be maintained.
 - e. If a pump local emergency stop is engaged or the corresponding suction pressure switch low P25-PSL-0251-1 through P25-PSL-0251-4 actuates, the corresponding pump trips offline and an alarm is generated.

- f. Local indication of pump discharge pressure is provided by P25-PI-0251-1 through P25-PI-0251-4.

C. Loop 0252 Backwash Sludge Pumping

- 1. Coagulated solids are collected at the bottom of each backwash tank cell. Each tank cell is equipped with a motor-operated discharge valve to permit solids effluent flow to the backwash sludge pump header and backwash sludge pumps. Solids effluent through the backwash tank cells flows to the backwash recycle pump header. Each backwash sludge pump sends sludge from the header pipe to the site sanitary sewer.
- 2. P25-PMP-0252-1 and P25-PMP-0252-2
 - a. Each backwash sludge pump can be assigned into and out of service as necessary by the operator.
 - b. Pump running, pump emergency stop status, pump in remote status, and motor overload is monitored for each pump. Motor overload generates an alarm.
 - c. In automatic, the SCADA system starts and stops the sludge pumps when one cell is settling and decanting. After filling is complete of a cell, and an operator selected timer setpoint, the corresponding cell sludge valve opens and a sludge pumps starts. The sludge pump runs throughout the settling phase and decant phase. The pump shuts off, after an operator selected timer setpoint, before the decant phase is complete
 - d. If a pump local emergency stop is engaged, the corresponding pump trips offline and an alarm is generated.
 - e. Local indication of pump discharge pressure is provided by P25-PI-0252-1 and P25-PI-0252-2.

2.07 CHEMICAL WASTE

A. Loop 0253 Chemical Waste Tank and Pumping

- 1. Chemical waste is collected from the CIP skids and chlorine gas scrubber. The chemical waste tank is equipped with two downstream pumps to send chemical waste to the site sanitary sewer.
- 2. Chemical Waste Tank Level
 - a. Liquid level in the chemical waste tank is measured by P25-LIT-0253-1. If the level in the tank reaches an operator-defined maximum level, and alarm is generated.
- 3. P25-PMP-0253-1 and P25-PMP-0253-2

- a. The operator can assign the chemical waste pumps into and out of service as necessary.
 - b. Pump running, pump emergency stop status, pump in remote status, and motor overload is monitored for each pump. Motor overload generates an alarm.
 - c. In automatic, the SCADA system will start and stop the chemical waste pumps based on the level in the chemical waste tank. The pumps alternate on each pump cycle or after an operator defined runtime setpoint.
 - d. If a pump local emergency stop is engaged, the corresponding pump trips offline and an alarm is generated.
 - e. Local indication of pump discharge pressure is provided by P25-PI-0253-1 and P25-PI-0253-2.
4. P25-FV-0253-1A
- a. Discharge flow from the chemical waste pumps is controlled by a motor-operated valve.
 - b. The operator may select between local operation of the discharge valve in the field or remote operation by the SCADA system.
 - c. If needed, the operator may locally or remotely open or close the motor-actuated valve to adjust the flow of chemical waste discharge to the site sanitary sewer.
 - d. Valve position fully open and fully closed limit switches are monitored and displayed.
 - e. If a valve motor actuator fails, an alarm is generated.
5. Backwash Sludge Discharge Flow
- a. Backwash sludge pumped from the backwash sludge pumps to the sump is measured by electromagnetic flow meter P25-FE/FIT-0253-3.
6. Chemical Waste Discharge Analyzers
- a. pH and ORP of the sump discharge to the site sanitary sewer is measured by P25-AIT-0254-1 and P25-AIT-0254-2. If discharge pH or ORP exceeds an operator-programmable maximum setpoint, an alarm is generated.

2.08 HIGH PRESSURE AIR SYSTEM

A. Loop 0231 Air Compression, Drying, and Storage

1. The compressed air system will be supplied by the UF system vendor. Each compressor will be equipped with a local control panel to monitor and control the compressors. The Main UF control panel will monitor and control all pneumatic supply, dryers, filters, and air receivers, as well as all control valves and all related skid-mounted instrumentation. Refer to specification Section 46 61 33 for additional details, requirements, and control descriptions.

2.09 CHLORINE GAS STORAGE AND INJECTION

A. Loop 0301 Chlorine Storage and Distribution

1. Chlorine gas is stored in three 2000 lb chlorine gas cylinders. A vacuum is induced when water passes through four downstream chlorinator injectors, which causes the chlorine gas in the in-service cylinder to be drawn out and into the four chlorinators. The chlorinators send the chlorine gas to the injectors and monitor the vacuum pressure, gas temperature, and other process variables to ensure uniform injection of chlorine gas.
2. P25-RGL-0301-1 & CGC-0301-1
 - a. Chlorine gas is stored in a 2000 lb cylinder mounted to a scale system equipped with a weight scale P25-WIT-0301-1. The weight scale is displayed on SCADA and is visually displayed on a remote-mounted monitoring panel device P25-WI-0301-1. When the weight scale reaches an operator-defined low setpoint an alarm is generated. The SCADA trending shall report the pounds of chlorine fed per day to each application point (process water and UF cleaning system water).
 - b. The cylinder vacuum regulator is equipped with high- and low-pressure switches that control the opening and closing of the regulator to permit or restrict the flow of gas in the presence or absence of a vacuum in the gas feed piping. A temperature-switch controlled heater is provided in the event that the ambient temperature drops below an operator-defined setpoint.
 - c. When the cylinder is in service and reaches its minimum level, the vacuum regulator of the other cylinder not in service automatically changes state in the presence of the vacuum to take over chlorine gas dispensing.
3. P25-RGL-0301-2 & CGC-0301-2
 - a. Chlorine gas is stored in a 2000 lb cylinder mounted to a scale system equipped with a weight scale P25-WIT-0301-2. The weight scale is displayed on SCADA and is visually displayed on a remote-mounted monitoring panel device P25-WI-0301-2. When the weight scale reaches an operator-defined low setpoint an alarm is generated. The SCADA trending shall report the pounds of chlorine fed per day to each application point (process water and UF cleaning system water).

- b. The cylinder vacuum regulator is equipped with high- and low-pressure switches that control the opening and closing of the regulator to permit or restrict the flow of gas in the presence or absence of a vacuum in the gas feed piping. A temperature-switch controlled heater is provided in the event that the ambient temperature drops below an operator-defined setpoint.
 - c. When the cylinder is in service and reaches its minimum level, the vacuum regulator of the other cylinder not in service automatically changes state in the presence of the vacuum to take over chlorine gas dispensing.
- 4. P25-RGL-0301-3 & CGC-0301-3
 - a. Chlorine gas is stored in a 2000 lb cylinder mounted to a scale system equipped with a weight scale P25-WIT-0301-3. The weight scale is displayed on SCADA and is visually displayed on a remote-mounted monitoring panel device P25-WI-0301-2. When the weight scale reaches an operator-defined low setpoint an alarm is generated. The SCADA trending shall report the pounds of chlorine fed per day to each application point (process water and UF cleaning system water).
 - b. The cylinder vacuum regulator is equipped with high- and low-pressure switches that control the opening and closing of the regulator to permit or restrict the flow of gas in the presence or absence of a vacuum in the gas feed piping. A temperature-switch controlled heater is provided in the event that the ambient temperature drops below an operator-defined setpoint.
 - c. When the cylinder is in service and reaches its minimum level, the vacuum regulator of the other cylinder not in service automatically changes state in the presence of the vacuum to take over chlorine gas dispensing.
- 5. P25-PE/PSH-0301-3
 - a. The presence of a vacuum in the chlorine gas feed pipe is monitored by an externally mounted pressure element and switch.
 - b. If the vacuum is disturbed for any reason, or the vacuum is lost, the pressure switch actuates and generated an alarm in the SCADA system and an externally-mounted alarm horn sounds.
- 6. P25-AE/AIT-0300-1 & P25-AE/AIR-0300-2
 - a. The presence of chlorine gas in the chlorine storage room is monitored by externally mounted analyzers and analyzer indicating transmitters.
 - b. Continuous real-time reading of the quantity of chlorine in the air is measured and subsequently displayed by SCADA. If the chlorine gas content in the room rises above a safe level, an alarm is generated and the emergency scrubber system engages.

7. P25-CL-0301-3, P25-CL-0301-4, P25-CL-0301-5 & P25-CL-0301-6
 - a. Four chlorinators monitor and control the flow of chlorine gas from the header pipe to the chlorine injectors.
 - b. Each chlorinator is monitored and controlled by a separately mounted local control device P25-AIT-0301-3, P25-AIT-0301-4, P25-AIT-0301-5, P25-AIT-0301-6. Each controller monitors the remote/local status of its corresponding chlorinator as well as the position of the chlorine gas discharge valve. The SCADA system monitors local control device status in remote and chlorinator discharge valve position for each chlorinator.
 - c. When a chlorinator is in automatic, an operator-defined chlorine gas dosing setpoint in the SCADA system is used to calculate corresponding open and close commands to the local control device to adjust the chlorinator discharge valve position.
 - d. When the chlorinator is in local, the operator may manually adjust the discharge valve position to adjust dosing of chlorine gas to the chlorine injectors.
 - e. Local indicator of chlorine gas flow through each chlorinator is provided by P25-FI-0301-3, P25-FI-0301-4, P25-FI-0301-5 and P25-FI-0301-6.
8. P25-PMP-0301-8 & P25-PMP-0301-9
 - a. UF filtrate is fed to the chlorinator booster pump header pipe as a source of motive water. Chlorine booster pumps 1 and 2 pump UF filtrate to chlorinator injectors 1 and 2 through an electromagnetic flow meter and motor-operated discharge valve.
 - b. These two pumps are dedicated to the UF cleaning system chlorine supply and configured in duty / standby. The operator can assign the pumps into and out of service as necessary.
 - c. Pump running, pump emergency stop status, pump in remote status, and motor overload is monitored for each pump. Motor overload generates an alarm.
 - d. In automatic, the SCADA system will start and stop the chlorinator booster pumps based on the status of the UF CIP skids calling for chlorinated water. .
 - e. If a pump local emergency stop is engaged, the corresponding pump trips offline and an alarm is generated.
 - f. Chlorinator booster pump discharge flow is measured by electromagnetic flow meter P25-FE/FIT-0301-8.

- g. Local pressure indication on the suction and discharge sides of injector P25-INJ-0301-12 is provided by P25-PI-0301-12A and P-25-PI-0301-12B, respectively.
 - h. Local pressure indication on the suction and discharge sides of injector P25-INJ-0301-13 is provided by P25-PI-0301-13A and P-25-PI-0301-13B, respectively.
9. P25-PMP-0301-10 & P25-PMP-0301-11
- a. UF filtrate is fed to the chlorinator booster pump header pipe as a source of motive water. Chlorine booster pumps 3 and 4 pump UF filtrate to chlorinator injectors 3 and 4 through an electromagnetic flow meter and motor-operated discharge valve.
 - b. The operator can assign the pumps into and out of service as necessary. These two pumps are dedicated to the process water with and chlorine can also be fed to the following application points:
 - (1) Clearwell cells 1 and two after ozone contact – normal operation
 - (2) Upstream of clearwell – optional feed when ozone is offline
 - (3) High service pump suction header – emergency use only when finished water chlorine residual is low
 - (4) Raw water – emergency use only as needed
 - c. Pump running, pump emergency stop status, pump in remote status, and motor overload is monitored for each pump. Motor overload generates an alarm.
 - d. In automatic, the SCADA system will start the selected chlorinator booster pump when the water plant is running and shut off the booster pump when the plant is off-line.
 - e. If a pump local emergency stop is engaged, the corresponding pump trips offline and an alarm is generated.
 - f. Chlorinator booster pump discharge flow is measured by electromagnetic flow meter P25-FE/FIT-0302-10.
 - g. Local pressure indication on the suction and discharge sides of injector P25-INJ-0301-14 is provided by P25-PI-0301-14A and P-25-PI-0301-14B, respectively.
 - h. Local pressure indication on the suction and discharge sides of injector P25-INJ-0301-15 is provided by P25-PI-0301-15A and P-25-PI-0301-15B, respectively.

10. Chlorine Gas Scrubber System P25-SK-0301-16

- a. In the event of a chlorine gas header pipe leak or other discharge of chlorine gas into the chlorine room, the chlorine emergency dry scrubber initiates and draws air out of the chlorine room through dry media and discharges it to atmosphere.
- b. The chlorine gas scrubber system is equipped with a vendor control panel that monitors and controls all instrumentation and equipment associated with the scrubber system. The scrubber local control panel is connected to the SCADA system and monitors scrubber in remote status, scrubber running, and scrubber blower motor overload.
- c. When the scrubber system starts or if the scrubber blower motor trips offline on a motor overload condition, an alarm is generated.

2.10 COAGULANT STORAGE AND INJECTION

A. Loop 0302 Coagulant Storage, Metering Pumps, and Flash Mix Pumps

1. P25-TNK-0302-1 & P25-TNK-0302-2

- a. Neat coagulant is stored in above ground storage tanks in the coagulant storage and pump room. Analog level in the first tank is measured by P25-LIT-0302-1 and a redundant level switch P25-LSH-0302-1 is provided for backup high level alarm condition. Analog level in the second tank is measured by P25-LIT-0302-2 and a redundant level switch P25-LSH-0302-2 is provided for backup high level alarm condition. When the level in a given tank reaches an operator-defined low level, an alarm is generated to indicate the need for refilling of the tank.
- b. In the event of a leak of coagulant in the coagulant storage and pump room, a sump with a level switch is provided. If the sump level switch actuates, an alarm is generated.
- c. Filling of the coagulant tanks is done manually at the outside truck fill connections. An audible horn sounds when a tank reaches full level as indicated by the coagulant tank level switches. External viewing of the tank levels and tank level switches is provided by P25-LI-0302-1/P25-LI-0302-2 and P25-YL-0302-1/P25-YL-0302-2.

2. P25-PMP-0302-3, P25-PMP-0302-4, & P25-PMP-0302-5

- a. The coagulant metering pumps are equipped with on-board VFDs.
- b. Pump running, pump emergency stop status, pump in remote, pump fail, pump tubing fail/leak, and pump speed feedback will be monitored for each pump. Pump fail and pump tubing fail/leak each generate an alarm.

- c. Operator setpoints include: coagulant dosage (mg/L as chemical), coagulant concentration (%), coagulant specific gravity (SG) (unitless)
- d. In automatic, the SCADA system will start, stop, and adjust the speed of the in-service metering pump based on the raw water flow into the plant and operator set dosage. Chemical flow rate, in gallons per hour, for metering pump speed pacing is calculated by the following equation:

$$\text{Chem Flow} = (\text{Process Flow} * \text{Dosage}) / (\text{Concentration} * \text{SG} * 24)$$

Where process flow is in MGD, dosage is mg/L as chemical, and concentration is % expressed as a decimal.

- e. The pumps may be placed remote manual mode at the pumps. In this mode, the operator may turn the pumps on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed will be maintained.
- f. If an operating pump fails, in automatic, the standby pump will start automatically and match the previous speed of the formerly operating pump.
- g. Local pressure indication is provided for each pump in the form of P25-PI-0302-3 and P25-PI-0302-4, respectively.

3. P25-PMP-0302-5 & P25-PMP-0302-6

- a. Redundant coagulant flash mix pumps are provided with VFDs. Pumps will run when coagulant is being fed by the coagulant metering pumps.
- b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for each pump. VFD fail generates an alarm.
- c. In automatic, the SCADA system will start, stop, and adjust the speed of one flash mix pump based on the influent flow of raw water from the river intake structure. Under normal operations, one flash mix pump is offline in standby.
- d. The pumps may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed will be maintained.
- e. If the pump local emergency stop is engaged, or suction pressure switch P25-PSL-0302-5 or PSL-0302-5 actuate, the pump will trip offline and an alarm will be generated.
- f. If one coagulant flash mix pump trips offline or otherwise fails, in automatic the SCADA system will start the standby pump and resume operating at the last speed of the previously operating pump.

2.11 SODIUM BISULFITE STORAGE AND INJECTION

A. Loop 0303 Sodium Bisulfite Storage and Metering Pumps

1. P25-TNK-0303-1

- a. High concentration sodium bisulfite solution is stored in an above ground storage tank in the sodium bisulfite storage and pump room. Analog level in the tank is measured by P25-LIT-0303-1 and a redundant level switch P25-LSH-0303-1 is provided for additional level feedback. When the level in the tank reaches an operator-defined low level, an alarm is generated to indicate the need for refilling of the tank.
- b. In the event of a leak of sodium bisulfite solution in the sodium bisulfite storage and pump room, a sump with a level switch is provided. If the sump level switch actuates, an alarm is generated.
- c. Filling of the sodium bisulfite tank is done manually at the outside truck fill connection. An audible horn sounds when the tank reaches full level as indicated by the sodium bisulfite tank level switch. External viewing of the tank level and tank level switch is provided by LI-0302-1 and YL-0302-1.

2. Sodium Bisulfite Chemical Injection Skid P25-SK-0303-3

- a. Redundant sodium bisulfite metering pumps are equipped with on-board VFDs.
- b. Pump running, pump emergency stop status, pump in remote, pump fail, pump tubing fail/leak, and pump speed feedback will be monitored for each pump. Pump fail and pump tubing fail/leak each generate an alarm.
- c. In automatic, the SCADA system will start, stop, and adjust the speed of the in-service metering pump based on the level in the chemical waste tank and the discharge flow of the chemical waste pumps to the sanitary sewer to maintain an operator-selected regulatory pH setpoint.
- d. The pumps may be placed remote manual mode at the pumps. In this mode, the operator may turn the pumps on or off and set the speed of the pumps accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed will be maintained.
- e. If an operating pump fails, in automatic, the standby pump will start automatically and match the previous speed of the formerly operating pump.
- f. Local pressure indication is provided for each pump.

3. Sodium Bisulfite Chemical Injection Skid P25-SK-0303-5

- a. Redundant sodium bisulfite metering are equipped with on-board VFDs.
- b. Pump running, pump emergency stop status, pump in remote, pump fail, pump tubing fail/leak, and pump speed feedback will be monitored for each pump. Pump fail and pump tubing fail/leak each generate an alarm.
- c. In automatic, the SCADA system will start, stop, and adjust the speed of the in-service metering pump based on the level in the clearwells.
- d. The pumps may be placed in remote manual mode at the pumps. In this mode, the operator may turn the pumps on or off and set the speed of the pumps accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed will be maintained.
- e. If an operating pump fails, in automatic, the standby pump will start automatically and match the previous speed of the formerly operating pump.
- f. Local pressure indication is provided for each pump.

2.12 CITRIC ACID STORAGE AND INJECTION

A. Loop 0304 Citric Acid Storage Totes and Metering Pumps

1. P25-TNK-0304-1 & P25-TNK-0304-2

- a. Citric acid is stored in two manually connected storage totes. Only one storage tote may be connected to the citric acid pumping system at a time.

2. P25-PMP-0304-1, P25-PMP-0304-2, P25-SV-0304-1A, & P25-SV-0304-2A

- a. Two air diaphragm citric acid metering pumps are provided. These pumps have no electrical or controls interface and work strictly on compressed air.
- b. Compressed air supply to each pump is provided through electrically actuated solenoid valves at each pump.
- c. The operator may operate the valve locally in the field or remote operation by the SCADA system.
- d. When in operation by the SCADA system, the position of the air valves is determined by the call for citric acid from the UF CIP skids.
- e. If needed, the operator may locally or remotely open or close the electrically actuated solenoid valve to permit or stop the flow of air to the in-service citric acid metering pump.

3. P25-SV-0304-3A & P25-SV-0304-3B

- a. Effluent citric acid through the citric acid metering pumps is controlled by electrically actuated solenoid valves that permit flow of citric acid to the UF CIP Skids.
- b. The operator may operate the valves locally in the field or remote operation by the SCADA system.
- c. When in operation by the SCADA system, the position of the citric acid pump discharge valves will be determined by the call for citric acid from the UF CIP skids.
- d. If needed, the operator may locally or remotely open or close the electrically actuated solenoid valve to permit or stop the flow of citric acid to each respective UF CIP Skid.

2.13 SODIUM HYPOCHLORITE STORAGE AND INJECTION

A. Loop 0310 Sodium Hypochlorite Storage Totes and Metering Pumps

1. P25-TNK-0310-1 & P25-TNK-0310-2

- a. Sodium hypochlorite is stored in two manually connected storage totes. Only one storage tote may be connected to the citric acid pumping system at a time.

2. P25-PMP-0310-1, P25-PMP-0310-2, P25-SV-0310-1A, & P25-SV-0310-2A

- a. Two air diaphragm sodium hypochlorite metering pumps are provided. These pumps have no electrical or controls interface and work strictly on compressed air.
- b. Compressed air supply to each pump is provided through electrically actuated solenoid valves at each pump.
- c. The operator may select between local operation of the valve in the field or remote operation by the SCADA system.
- d. When in operation by the SCADA system, the position of the air valves is determined by the call for sodium hypochlorite from the UF CIP skids.
- e. If needed, the operator may locally or remotely open or close the electrically actuated solenoid valves to permit or stop the flow of air to the in-service sodium hypochlorite metering pump.

3. P25-SV-0310-3A & P25-SV-0310-3B

- a. Effluent sodium hypochlorite through the sodium hypochlorite metering pumps is controlled by electrically actuated solenoid valves that permit flow of sodium hypochlorite to the UF CIP Skids.

- b. The operator may select between local operation of the valves in the field or remote operation by the SCADA system.
- c. When in operation by the SCADA system, the position of the sodium hypochlorite pump discharge valves will be determined by the call for sodium hypochlorite from the UF CIP skids.
- d. If needed, the operator may locally or remotely open or close the electrically actuated solenoid valve to permit or stop the flow of sodium hypochlorite to each respective UF CIP Skid.

2.14 BACKWASH SUPPLY

A. Loop 0240 Backwash Supply Tank Cells

1. Backwash Supply Tank Cell 1 Influent Modulating Valves P25-FV-0240-1A and P25-FV-0240-1B
 - a. Filtrate effluent from the UF skids is continuously sent to the backwash supply tank to maintain an operator-selectable level setpoint.
 - b. The operator may select between local operation of the influent valves in the field or remote operation by the SCADA system.
 - c. If needed, the operator may locally or remotely open or close the motor-actuated valves to adjust the flow of effluent filtrate into the backwash supply tank cell.
 - d. Valve position, valve fully open and valve fully closed limit switches are displayed.
 - e. If a valve motor actuator fails, an alarm is generated.
 - f. Level in the backwash supply tank cell is monitored by P25-LIT-0241-6A. As the level in the cell increases, the influent modulating valve is closed to maintain the operator-selectable level setpoint. If the level in the cell reaches an operator-defined maximum setpoint, an alarm is generated. If an operator-defined minimum level setpoint is reached, an alarm is generated. Level switch P25-LSH-0240-1 is provided for redundant maximum level monitoring in the cell.
2. Backwash Supply Tank Cell 2 Influent Modulating Valves P25-FV-0240-2A and P25-FV-0240-2B
 - a. Filtrate effluent from the UF skids is continuously sent to the backwash supply tank to maintain an operator-selectable level setpoint.

- b. The operator may select between local operation of the influent valves in the field or remote operation by the SCADA system.
 - c. If needed, the operator may locally or remotely open or close the motor-actuated valve to adjust the flow of effluent filtrate into the backwash supply tank cell.
 - d. Valve position, valve fully open and valve fully closed limit switches is displayed.
 - e. If a valve motor actuator fails, an alarm is generated.
 - f. Level in the backwash supply tank cell is monitored by P25-LIT-0241-6B. As the level in the cell increases, the influent modulating valve is closed to maintain the operator-selectable level setpoint. If the level in the cell reaches an operator-defined maximum setpoint, an alarm is generated. If an operator-defined minimum level setpoint is reached, an alarm is generated. Level switch P25-LSH-0240-2 is provided for redundant maximum level monitoring in the cell.
3. UF Backwash Pumps P25-PMP-0241-1, P25-PMP-0241-2, P25-PMP-0241-3
- a. Each UF backwash pump is equipped with a VFD. The pumps are provided in a lead, lag, and standby configuration with the roles of each pump rotating automatically after each backwash cycle. The operator can assign the pumps into and out of service as necessary.
 - b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for each pump. VFD fail generates an alarm.
 - c. In automatic, the SCADA system will start and stop the UF backwash pumps based on the levels in the backwash supply tank cells and the quantity of UF Skids calling for a backwash cycle. The first pump starts and ramps up speed to produce the required flow. Once the lead pump reaches full speed and subsequent additional flow is required, the lag pump starts at minimum speed and the first pump matches speed. The speed of both pumps is then increased until maximum flow is reached when both pumps are at full speed.
 - d. Each pump may be placed in remote manual mode at the VFD. In this mode, the operator may turn the pumps on or off and set the speed of the pump accordingly. If a pump is running and it is placed into or out of remote manual mode, the pump run status and running speed is maintained.
 - e. If a pump local emergency stop is engaged, or if suction pressure switches P25-PSL-0241-1/2/3 actuate, respectively, the corresponding pump trips offline and an alarm is generated.

- f. Local indication of pump discharge pressure is provided by P25-PI-0241-1 through P25-PI-0241-3.

2.15 OXYGEN STORAGE & OZONE GENERATION AND INJECTION

A. Loop 0305 Ozone Generation & Liquid Oxygen Storage

1. P25-MCP-0305-1

- a. The subsequent liquid oxygen storage skid local vendor control panel will be connected via Ethernet to the ozone main vendor control panel. All other skids associated with the ozone system will be hard-wired to the ozone main vendor control panel. The following points at a minimum will be monitored and displayed for the ozone system via the ozone system main vendor control panel:

- (1) Ozone System Running
- (2) Ozone System General Trouble Alarm
- (3) Ozone Generating Room Ozone Level Warning
- (4) Ozone Generating Room Ozone Level Alarm
- (5) Ozone Generating Room Oxygen Level Warning
- (6) Ozone Generating Room Oxygen Level Alarm
- (7) Nitrogen Storage Tank Pressure Alarm High
- (8) Nitrogen Storage Tank Pressure Alarm Low
- (9) Ozone Generator 1 Running
- (10) Ozone Generator 2 Running
- (11) Ozone Generator 3 Running
- (12) Ozone Generator 4 Running

- b. The Manufacturer's MCP will automatically control:

- (1) Ozone generation system start-up and shutdown
- (2) sequencing of increasing or decreasing the quantity of ozone generated and injected

- 2. The liquid oxygen storage skid will be equipped with a local vendor control panel to monitor and control the storage tank and vaporizers, as well as monitor and

control all control valves and all related skid-mounted instrumentation. Refer to specification Section 46 31 53 for additional details, requirements, and control descriptions.

3. P25-LCP-0305-1 Liquid Oxygen Storage Local Control Panel

- a. The local vendor control panel will be connected via Ethernet to the Ozone main vendor control panel P25-MCP-0305-1. The following points at a minimum will be monitored and displayed for the liquid oxygen storage skid:

- (1) Liquid Oxygen Storage Tank Level
- (2) Liquid Oxygen Storage Tank Pressure
- (3) Liquid Oxygen System Trouble Alarm

B. Loop 0306 GOX Regulating Manifold

1. The GOX regulating manifold skid heats and filters the vaporized oxygen before it is combined with nitrogen. All equipment, control valves, and skid-mounted instrumentation will be monitored and controlled by the ozone main vendor control panel P25-MCP-0305-1. Refer to specification Section 46 31 53 for additional details, requirements, and control descriptions.

C. Loop 0307 Nitrogen Boost Compressor System Skid

1. The nitrogen boost compressor system skid stores, filters, and vaporizes nitrogen before it is combined with oxygen at the GOX regulating manifold. All equipment, control valves, and skid-mounted instrumentation will be monitored and controlled by the ozone main vendor control panel P25-MCP-0305-1. Refer to specification Section 46 31 53 for additional details, requirements, and control descriptions.

D. Loop 0308 Ozone Generators

1. Each ozone generator receives GOX from the GOX regulating manifold and produces ozone. Each ozone generator is equipped with a local control panel. All equipment, control valves, and skid-mounted instrumentation will be monitored and controlled by the local control panels, which are monitored and controlled by the ozone main vendor control panel P25-MCP-0305-1. Refer to specification Section 46 31 53 for additional details, requirements, and control descriptions.

E. Loop 0309 Cooling Water System

1. Ozone chillers are provided to chill the ozone produced by the ozone generators before it is sent to the ozone injection skid. All equipment, control valves, and skid-mounted instrumentation for each ozone chiller will be monitored and controlled by the ozone main vendor control panel P25-MCP-0305-1. Refer to specification Section 46 31 53 for additional details, requirements, and control descriptions.

F. Loop 0310 Ozone Injection Pump Skid

1. Chilled ozone from the ozone generators is sent to the ozone injection pump skid where it is combined with UF skid filtrate water before being pumped to the clearwells. The ozone injection pump skid is provided with two peristaltic metering pumps each equipped with an on-board VFD.
2. All equipment, control valves, and skid-mounted instrumentation will be monitored and controlled by the ozone main vendor control panel P25-MCP-0305-1. Refer to specification Section 46 31 53 for additional details, requirements, and control descriptions.
3. Influent filtrate water to the ozone injection pump skid is monitored and measured by electromagnetic flow meter P25-FE/FIT-0306-9.

2.16 TREATED WATER CLEARWELL

A. Loop 0401 Clearwell East Cell

1. Level in the clearwell east cell is provided by P25-LIT-0401-1.
2. Roof access hatches are monitored by position switches P25-ZSC-0401-1, P25-ZSC-0401-2, P25-ZSC-0401-3.
3. P25-PMP-0401-4 & P25-AE/AIT-0401-1A Clearwell Sampling
 - a. Ozonated water is drawn out of the clearwell by a sample pump.
 - b. Sample pump motor running, in remote, and overload is monitored by the SCADA system. In remote, the SCADA system can start and stop the sample pump.
 - c. Sample water passes through an ORP analyzer to monitor and measure the oxidation-reduction potential of the ozonated water. If the ORP of the sample water is outside of an operator-defined range, an alarm is generated.
4. P25-PMP-0401-5 & P25-AE/AIT-0401-1B Clearwell Sampling
 - a. Ozonated water is drawn out of the clearwell by a fractional horsepower sample pump.
 - b. Sample pump motor running, in remote, and overload is monitored by the SCADA system. In remote, the SCADA system can start and stop the sample pump.
 - c. Sample water passes through an ORP analyzer to monitor and measure the oxidation-reduction potential of the ozonated water. If the ORP of the sample water is outside of an operator-defined range, an alarm is generated.

5. Emergency Overflow Trough
 - a. The presence of water in the overflow trough is monitored by P25-LSH-0401-1. If this level switch actuates an alarm is generated.
- B. Loop 0402 Clearwell West Cell
 1. Level in the clearwell east cell is provided by P25-LIT-0402-1.
 2. Roof access hatches are monitored by position switches P25-ZSC-0402-1, P25-ZSC-0402-2, P25-ZSC-0402-3.
 3. P25-PMP-0402-4 & P25-AE/AIT-0402-1A Clearwell Sampling
 - a. Ozonated water is drawn out of the clearwell by a fractional horsepower sample pump.
 - b. Sample pump motor running, in remote, and overload is monitored by the SCADA system. In remote, the SCADA system can start and stop the sample pump.
 - c. Sample water passes through an ORP analyzer to monitor and measure the oxidation-reduction potential of the ozonated water. If the ORP of the sample water is outside of an operator-defined range, an alarm is generated.
 4. P25-PMP-0402-5 & P25-AE/AIT-0402-1B Clearwell Sampling
 - a. Ozonated water is drawn out of the clearwell by a fractional horsepower sample pump.
 - b. Sample pump motor running, in remote, and overload is monitored by the SCADA system. In remote, the SCADA system can start and stop the sample pump.
 - c. Sample water passes through an ORP analyzer to monitor and measure the oxidation-reduction potential of the ozonated water. If the ORP of the sample water is outside of an operator-defined range, an alarm is generated.
- C. Loop 0403 Clearwell Drain Vault
 1. P25-PMP-0403-1 & P25-LCP-0403-1 Clearwell Drain Pump
 - a. Manual drain valves may be opened to drain each clearwell cell to the drain vault. The drain vault is supplied with a small sump pump.
 - b. Pressure in each drain line to the suction side of drain pump P25-PMP-0403-1 is monitored by P25-PIT-0403-1A and P25-0403-1B.

- c. The sump pump is provided with a local control panel that is operated in manual when clearwell draining is required.
 - d. The sump pump pumps water to the emergency overflow box which diverts water to the Mill Race Canal.
- 2. P25-PMP-0403-2 Clearwell Drain Vault Sump Pump
 - a. P25-PMP-0403-2 is equipped with an on-board level switch that turns the pump on and off based on the level of water in the drain vault.
 - b. P25-LSHH-0403-1 is provided in the drain vault if P25-PMP-0403-2 malfunctions. If the level switch actuates, an alarm is generated.
- 3. Total residual chlorine discharged to the Mill Race Canal from the Drain Pump is measured by P25-AE/AIT-0403-1. If the Cl₂ level reaches above an operator set point, an alarm is generated.
- 4. P25-ZSO-0403-1 and P25-ZSO-0403-2 monitor the drain vault access hatches.

2.17 HIGH SERVICE PUMP STATION

- A. Finished water from the clearwell is pumped to the distribution system by five vertical turbine pumps. High Service Pumps 1 and 2 are sized at smaller capacity than High Service Pumps 3, 4, and 5. Upon start-up of the plant, one low capacity high service pump starts and begins to increase in speed. Upon reaching full speed, if the discharge pressure setpoint is not reached, the second low capacity high service pump starts at minimum speed and the initial low capacity pump matches speed. Both pumps increase in speed until full speed is reached. This cycle is repeated with the three large capacity pumps until all four pumps are operating at full capacity for a total of 30 MGD. If the level in the East or West clearwell drops below an operator defined setpoint as measured by LIT-0401-1 and LIT-0402-1, all pumps shall trip offline.
- B. Loop 0411 High Service Pump 1
 - 1. P25-PMP-0411-1
 - a. High Service Pump 1 is equipped with a VFD. The operator can assign the pump into and out of service as necessary.
 - b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for the pump. VFD fail generates an alarm.
 - c. In automatic, the SCADA system can start, stop, and adjust the speed of the high service pump based on an operator-defined setpoint to maintain discharge pressure in the distribution system as described above.

- d. The pump may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed is maintained.
- e. If the pump local emergency stop is engaged, the pump trips offline and an alarm is generated.
- f. Motor winding and motor bearing RTD's P25-TE-0411-1A through P25-TE-0411-1H are provided for temperature monitoring of the pump/motor assembly. Vibration monitoring is also provided by P25-VE-0411-1.
- g. Pump discharge valve P25-FCV-0411-1 is interlocked with the start-up and shutdown sequence of the pump. Upon start-up of the pump, the valve will begin opening upon actuation of discharge pressure switch P25-PSH-0411-1. When the discharge pressure setpoint is reached, an operator-defined timer begins. At the conclusion of this timer setpoint, coordinated with the pump vendor during start-up and commissioning, if the discharge valve has not reached 100% open position, as measured by a valve-mounted limit switch, the pump trips offline and an alarm is generated. The valve is also supplied with a 100% closed limit switch and a 95% closed limit switch. During a shutdown sequence of the pump, the pump trips offline when the discharge valve reaches 95% closed.

C. Loop 0412 High Service Pump 2

1. P25-PMP-0412-1

- a. High Service Pump 2 is equipped with a VFD. The operator can assign the pump into and out of service as necessary.
- b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for the pump. VFD fail generates an alarm.
- c. In automatic, the SCADA system can start, stop, and adjust the speed of the high service pump based on an operator-defined setpoint to maintain discharge pressure in the distribution system as described above.
- d. The pump may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed is maintained.
- e. If the pump local emergency stop is engaged, the pump trips offline and an alarm is generated.

- f. Motor winding and motor bearing RTD's P25-TE-0412-1A through P25-TE-0412-1H are provided for temperature monitoring of the pump/motor assembly. Vibration monitoring is also provided by P25-VE-0412-1.
- g. Pump discharge valve P25-FCV-0412-1 is interlocked with the start-up and shutdown sequence of the pump. Upon start-up of the pump, the valve will begin opening upon actuation of discharge pressure switch P25-PSH-0412-1. When the discharge pressure setpoint is reached, an operator-defined timer begins. At the conclusion of this timer setpoint, coordinated with the pump vendor during start-up and commissioning, if the discharge valve as not reached 100% open position, as measured by a valve-mounted limit switch, the pump trips offline and an alarm is generated. The valve is also supplied with a 100% closed limit switch and a 95% closed limit switch. During a shutdown sequence of the pump, the pump trips offline when the discharge valve reaches 95% closed.

D. Loop 0413 High Service Pump 3

1. P25-PMP-0413-1

- a. High Service Pump 3 is equipped with a VFD. The operator can assign the pump into and out of service as necessary.
- b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for the pump. VFD fail generates an alarm.
- c. In automatic, the SCADA system can start, stop, and adjust the speed of the high service pump based on an operator-defined setpoint to maintain discharge pressure in the distribution system as described above.
- d. The pump may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed is maintained.
- e. If the pump local emergency stop is engaged, the pump trips offline and an alarm is generated.
- f. Motor winding and motor bearing RTD's P25-TE-0413-1A through P25-TE-0413-1H are provided for temperature monitoring of the pump/motor assembly. Vibration monitoring is also provided by P25-VE-0413-1.
- g. Pump discharge valve P25-FCV-0413-1 is interlocked with the start-up and shutdown sequence of the pump. Upon start-up of the pump, the valve will begin opening upon actuation of discharge pressure switch P25-PSH-0413-1. When the discharge pressure setpoint is reached, an operator-defined timer begins. At the conclusion of this timer setpoint, coordinated with the pump vendor during start-up and commissioning, if the discharge valve as not

reached 100% open position, as measured by a valve-mounted limit switch, the pump trips offline and an alarm is generated. The valve is also supplied with a 100% closed limit switch and a 95% closed limit switch. During a shutdown sequence of the pump, the pump trips offline when the discharge valve reaches 95% closed.

E. Loop 0414 High Service Pump 4

1. P25-PMP-0414-1

- a. High Service Pump 4 is equipped with a VFD. The operator can assign the pump into and out of service as necessary.
- b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for the pump. VFD fail generates an alarm.
- c. In automatic, the SCADA system can start, stop, and adjust the speed of the high service pump based on an operator-defined setpoint to maintain discharge pressure in the distribution system as described above.
- d. The pump may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed is maintained.
- e. If the pump local emergency stop is engaged, the pump trips offline and an alarm is generated.
- f. Motor winding and motor bearing RTD's P25-TE-0414-1A through P25-TE-0414-1H are provided for temperature monitoring of the pump/motor assembly. Vibration monitoring is also provided by P25-VE-0414-1.
- g. Pump discharge valve P25-FCV-0414-1 is interlocked with the start-up and shutdown sequence of the pump. Upon start-up of the pump, the valve will begin opening upon actuation of discharge pressure switch P25-PSH-0414-1. When the discharge pressure setpoint is reached, an operator-defined timer begins. At the conclusion of this timer setpoint, coordinated with the pump vendor during start-up and commissioning, if the discharge valve as not reached 100% open position, as measured by a valve-mounted limit switch, the pump trips offline and an alarm is generated. The valve is also supplied with a 100% closed limit switch and a 95% closed limit switch. During a shutdown sequence of the pump, the pump trips offline when the discharge valve reaches 95% closed.

F. Loop 0415 High Service Pump 5

1. P25-PMP-0415-1

- a. High Service Pump 5 is equipped with a VFD. The operator can assign the pump into and out of service as necessary.
- b. Pump running, pump emergency stop status, VFD in remote, VFD fail, and VFD speed feedback is monitored for the pump. VFD fail generates an alarm.
- c. In automatic, the SCADA system can start, stop, and adjust the speed of the high service pump based on an operator-defined setpoint to maintain discharge pressure in the distribution system as described above.
- d. The pump may be placed remote manual mode at the VFD. In this mode, the operator may turn the pump on or off and set the speed of the pump accordingly. If the pump is running and it is placed into or out of remote manual mode, the pump run status and running speed is maintained.
- e. If the pump local emergency stop is engaged, the pump trips offline and an alarm is generated.
- f. Motor winding and motor bearing RTD's P25-TE-0415-1A through P25-TE-0415-1H are provided for temperature monitoring of the pump/motor assembly. Vibration monitoring is also provided by P25-VE-0415-1.
- g. Pump discharge valve P25-FCV-0415-1 is interlocked with the start-up and shutdown sequence of the pump. Upon start-up of the pump, the valve will begin opening upon actuation of discharge pressure switch P25-PSH-0415-1. When the discharge pressure setpoint is reached, an operator-defined timer begins. At the conclusion of this timer setpoint, coordinated with the pump vendor during start-up and commissioning, if the discharge valve as not reached 100% open position, as measured by a valve-mounted limit switch, the pump trips offline and an alarm is generated. The valve is also supplied with a 100% closed limit switch and a 95% closed limit switch. During a shutdown sequence of the pump, the pump trips offline when the discharge valve reaches 95% closed.

G. Loop 0416 High Service Pumps Suction Header

1. P25-PSL-0416-1

- a. Pressure of the finished water high service pumps suction header from the clearwell is monitored by a pipe-mounted pressure switch.
- b. If the pressure in the header pipe drops below the setpoint of the pressure switch, an alarm is generated and all operating high service pumps trip offline.

H. Loop 0417 High Service Pumps Discharge Header

1. P25-FE/FIT-0417-1 & P25-PI/PT-0417-1

- a. Flow through the finished water high service pumps discharge header is monitored by an electromagnetic flow meter. If no flow is measured when one or more pumps is running, an alarm is generated and all operating pumps trip offline.
- b. Pressure of the finished water high service pumps discharge header is monitored by pipe-mounted pressure transmitter. Local pressure indication is provided by a pressure indicator.
- c. P25-PMP-PMP-0417-1 is equipped with an on-board level switch to pump water out of the pump suction header
- d. Surge Bladders TNK-0417-1 and TNK-0417-2 are equipped with differential pressure indicating transmitters to monitor the pressures inside each tank.

I. Loop 0418 Finished Water Analyzers

1. P25-TIT-0418-1A & P25-AE/AIT-0418-1B

- a. Finished water from the high service pumps is sampled off the discharge header through a pressure control valve. The sampled water is analyzed for temperature and pH. If temperature falls above an operator-defined range setpoint, an alarm is generated. If pH falls outside the limits of an operator-defined acceptable range, an alarm is generated.

2.18 OZONE DESTRUCTION

- A. Ozone off gas from the two clearwell cells is first sent through one of two demister units P25-SK-0401-1 and P25-0402-1. Demister inlet pressure is monitored by pressure transmitters on the suction side of the demisters and differential pressure across each demister is monitored. An alarm is generated when differential pressure switch actuates.
- B. Demisted ozone is sent to ozone destruct units that are equipped with vendor-provided local control panels. Blowers in the ozone destruction units operate continuously to blow off residual gas to atmosphere. Ozone analyzers are provided at the outlet of the ozone destruction units to monitor the quantity of ozone. If the ozone in the blowoff air reaches a maximum operator-defined setpoint, an alarm is generated.

PART 3 EXECUTION

3.01 FIELD TESTING

- A. Comply with the requirements specified in Section 40 61 21.

3.02 DEMONSTRATION

- A. Comply with the requirements specified in Section 40 61 21.

3.03 CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 62 43

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide materials and installation of programmable logic controllers as indicated and in compliance with Contract Documents.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and Testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.
- B. National Fire Protection Agency (NFPA):
 - 1. 70: National Electrical Code (NEC).
- C. Underwriters' Laboratories, Inc., (UL):
 - 1. 508: Electrical Industrial Control Equipment.
 - 2. 508A: Industrial Control Panels.
 - 3. 1059: Safety Terminal Blocks.

4. 1449: Surge Protective Devices.

1.03 SUBMITTALS

- A. Submit the following in accordance with Section 01 33 00.
 1. Manufacturer's descriptive data, technical literature, and detailed specifications for product. Data shall include complete lists of all required options, parts, and supplies with current unit prices and source of supply.
 2. Dimensioned outline(s).
 3. Installation instructions and detail(s).
 4. Operation and Maintenance Manual containing the Supplier's operating and maintenance instructions for the instrument in accordance with the Statement of Work.
 5. Electrical wiring schematic(s).

PART 2 - PRODUCTS

2.01 COMMON REQUIREMENTS

- A. Total minimum I/O interface capability as specified and shown on Drawings and the I/O List.
 1. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
 2. Provide 25 percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
- B. Provide additional racks within PLC-0000-1, RIO-0000-1, and PLC-0000-2 as necessary.
- C. Expandable.
- D. Modular.
- E. Accept discrete and analog input signals.
- F. Control discrete and analog output signals.
- G. Monitor signal status of input and output devices.
- H. Mounting hardware and interconnecting cables.
- I. Include status and fault monitoring.

2.02 COMMON PROCESSOR WITH MEMORY REQUIREMENTS

- A. Internal diagnostics shall be available to user for troubleshooting.
- B. Halt if any of following occur:
 - 1. Memory error.
 - 2. Communications error between CPU and I/O modules.
 - 3. Detection of application error.
- C. Battery backup or EEPROM to prevent program loss on power failure.
- D. Features/Functions:
 - 1. Contact/coil status.
 - 2. Latching/unlatch.
 - 3. Force I/O.
 - 4. Data transfer.
 - 5. Four function math.
 - 6. Counting.
 - 7. Timing.
 - 8. Self-monitoring diagnostics.
 - 9. Shift registers.
 - 10. Transitional coils.
 - 11. Master control relay.
 - 12. Subroutines.
 - 13. Matrix operations.
 - 14. Data comparisons.
 - 15. Internal diagnostics available to user.
 - 16. PID control.
 - 17. Network capabilities.

2.03 COMMON POWER SUPPLY REQUIREMENTS

- A. 24 V DC power input.
- B. Fused input.
- C. 0.2% load regulation.
- D. Sized for minimum of 125% of load.

2.04 COMMON PROGRAMMING SOFTWARE REQUIREMENTS

- A. Manufacturer's software compatible with programmable logic controllers and PC hardware and software specified.
- B. PLC Programming Software shall provide capability to:
 - 1. Program PLC features/functions off-line.
 - 2. Display on-line status of I/O and registers.
 - 3. Symbols similar to conventional relay logic symbols.
 - 4. Search function.
 - 5. Edit program.
 - 6. Display error code registers.
 - 7. Connect programming PC to PLC through network.
 - 8. Security via user-defined password.
 - 9. Printout program.
 - 10. Programming annotation.
 - 11. Load and record contents of memory.

2.05 MEDIUM PLCS

- A. Manufacturers:
 - 1. Allen Bradley, 5069-L320E or higher.
 - 2. No substitution is permitted.
- B. Additional Design Requirements:
 - 1. Capable of:

- a. Operating in temperatures of 0°C to 60°C.
- b. Operating in humidity of 5% to 95%, non-condensing.

C. Chassis:

- 1. Modular.
- 2. Integral or remote power supply.
- 3. Capability to accept:
 - a. Processor.
 - b. Memory.
 - c. I/O modules.
 - d. Communications modules installed in chassis backplane
 - e. Modbus/TCP & Ethernet/IP Module: Allen-Bradley 1756-EN2T.
- 4. Minimum of 12 slots per chassis.

D. Additional Processor With Memory Requirements:

- 1. Size memory with reserve capacity of 50%.
- 2. Additional Features/Functions:
 - a. Clock and Calendar.
 - b. Multiple network capabilities.
 - c. Multiple independent asynchronous scans.
 - d. On line programming.
 - e. Symbolic addressing.
 - f. Ladder and function block diagram programming languages.
 - g. Multiple processors can share common input data.
 - h. Pre-emptive multi-tasking operating system.
 - i. Advanced instruction set including file handling, sequencer, diagnostic, shift register, program control, ASCII, function blocks, and motion control instructions.

E. Additional Power Supply Requirements:

1. Short circuit current limit protection.
2. Crowbar over-voltage protection.

F. I/O Modules:

1. General:

- a. Shield against electrical noise and RF.
- b. Provide optical isolation to give 1,500 vdc isolation from wiring on other I/O modules.
- c. Provide I/O wiring screw terminals:
 - (1) I/O wiring screw terminals shall be removable so as not to disturb user wiring when replacing defective module.
- d. Design modules to be installed or removed while chassis power is applied.
- e. Front of module LED for module status and alarm indication:
 - (1) Point level status and alarm on discrete I/O modules.
- f. Configure modules through software.
- g. Point level fusing on discrete I/O modules.
- h. Program retrievable module identification.

2. Analog Input Modules:

- a. Accept 1-5 vdc or 4-20 mAdc analog signals.
- b. Resolution: 16 bit.
 - (1) Current Resolution: 1 microamp per bit.
 - (2) Voltage Resolution: 1 microvolts per bit.
- c. Open circuit detection.
- d. Point to point isolation.
- e. Over voltage protection.
- f. Noise rejection.

- g. Each channel can individually have HART enabled or disabled.
 - 3. Analog Output Modules:
 - a. Output 1-5 vdc or 4-20 mAdc analog signals.
 - b. Resolution: 13 bit.
 - c. Point to point isolation.
 - d. Over voltage protection.
 - e. Short circuit protection.
 - 4. Discrete Input Modules:
 - a. Monitor contact openings and closures from panel and field devices.
 - b. Individually isolated 24 V DC type.
 - c. LED lights for each input to indicate status.
 - 5. Discrete Output Modules:
 - a. Provide contact openings and closures to panel and field devices.
 - b. Each output to have indicator light to show output status.
 - c. Individually isolated.
 - d. 24 V DC output.
 - G. Additional Programming Software Requirements:
 - 1. Program PLC functions on-line and off-line.
 - 2. Upload and download contents of memory.
 - 3. Symbolic, function block, free form ladder, drag and drop editors, and text editor.
- 2.06 LARGE PLCS:
- A. Manufacturers:
 - 1. Allen Bradley, ControlLogix model 1756-L83E or higher.
 - 2. No substitution is permitted.

B. Additional Design Requirements:

1. Capable of:
 - a. Operating in temperatures of 0°C to 60°C.
 - b. Operating in humidity of 5% to 95%, non-condensing.

C. Chassis:

1. Modular.
2. Integral or remote power supply.
3. Capability to accept:
 - a. Processor.
 - b. Memory.
 - c. I/O modules.
 - d. Communications modules installed in chassis backplane
 - e. Modbus/TCP & Ethernet/IP Module: Allen-Bradley 1756-EN2T.
4. Minimum of 10 slots per chassis.

D. Additional Processor With Memory Requirements:

1. Size memory with reserve capacity of 50%.
2. Additional Features/Functions:
 - a. Clock and Calendar.
 - b. Multiple network capabilities.
 - c. Multiple independent asynchronous scans.
 - d. On line programming.
 - e. Symbolic addressing.
 - f. Ladder and function block diagram programming languages.
 - g. Multiple processors can share common input data.
 - h. Pre-emptive multi-tasking operating system.

- i. Advanced instruction set including file handling, sequencer, diagnostic, shift register, program control, ASCII, function blocks, and motion control instructions.
- E. Additional Power Supply Requirements:
 - 1. Short circuit current limit protection.
 - 2. Crowbar over-voltage protection.
- F. I/O Modules:
 - 1. General:
 - a. Shield against electrical noise and RF.
 - b. Provide optical isolation to give 1,500 vdc isolation from wiring on other I/O modules.
 - c. Provide I/O wiring screw terminals:
 - (1) I/O wiring screw terminals shall be removable so as not to disturb user wiring when replacing defective module.
 - d. Design modules to be installed or removed while chassis power is applied.
 - e. Front of module LED for module status and alarm indication:
 - (1) Point level status and alarm on discrete I/O modules.
 - f. Configure modules through software.
 - g. Point level fusing on discrete I/O modules.
 - h. Program retrievable module identification.
 - 2. Analog Input Modules 1756-IF8H:
 - a. Accept 1-5 vdc or 4-20 mAdc analog signals.
 - b. Resolution: 16 bit.
 - (1) Current Resolution: 1 microamp per bit.
 - (2) Voltage Resolution: 1 microvolts per bit.
 - c. Open circuit detection.
 - d. Point to point isolation.

- e. Over voltage protection.
 - f. Noise rejection.
 - g. Each channel can individually have HART enabled or disabled.
- 3. Analog Output Modules 1756-OF8I:
 - a. Output 1-5 vdc or 4-20 mAdc analog signals.
 - b. Resolution: 13 bit.
 - c. Point to point isolation.
 - d. Over voltage protection.
 - e. Short circuit protection.
- 4. Discrete Input Modules 1756-IA16:
 - a. Monitor contact openings and closures from panel and field devices.
 - b. Individually isolated 24 V DC type.
 - c. LED lights for each input to indicate status.
- 5. Discrete Output Modules 1756-OA16:
 - a. Provide contact openings and closures to panel and field devices.
 - b. Each output to have indicator light to show output status.
 - c. Individually isolated.
 - d. 24 V DC output.

G. Additional Programming Software Requirements:

- 1. Program PLC functions on-line and off-line.
- 2. Upload and download contents of memory.
- 3. Symbolic, function block, free form ladder, drag and drop editors, and text editor.

2.07 OIT EQUIPMENT

A. Manufacturers:

- 1. Allen Bradley, 2711P-T15 PanelView Plus 7 Performance.

2. No substitution is permitted.
 - B. The display shall be 15 inch capable of color graphics.
 - C. 24 VDC power supply with internal battery backup.
 - D. NEMA 4X environmental protection with hazardous area rating if required.
 - E. Program the HMI unit with latest version of FactoryTalk programming software.
 - F. The HMI shall be programmed to provide for the monitoring and control of all input and output points, loops and systems through graphic display screens. Additionally, the HMI programming shall include:
 1. Process parameter displays.
 2. Alarm management.
 3. Trending of key process variables.
 - G. Provide all necessary data files so that the control system can be integrated into the plant SCADA.
 - H. For all PLCs provided, provide all program files for end user modification and programs shall not be proprietary or require vendor for accessibility.
 - I. Provide all run-time licenses necessary for the operation of the new PLC and HMI installations.
- 2.08 CABLES
- A. Interconnecting cables.
 - B. Serial cable to connect programming PC to PLC's.
- 2.09 COMMUNICATIONS HARDWARE
- A. Provide communication protocols as specified.
 - B. Provide 500 vdc isolation between communication circuits.
- 2.10 SOURCE QUALITY CONTROL
- A. UL, CUL, and CSA approved. CE compliant for all applicable directives.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install and wire in accordance with manufacturer's written instructions and approved submittals.
- B. Program PLCs in Ladder Logic.

3.02 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 66 00

NETWORK AND COMMUNICATION EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide network and communication equipment as indicated and in compliance with Contract Documents.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM).
- B. Institute of Electrical and Electronic Engineers (IEEE)
- C. International Standards Organization/International Electrotechnical Commission (ISO/IEC):
 - 1. 11801: Information Technology – Generic cabling for customer premises.
- D. National Electrical Manufacturers Association (NEMA).
- E. National Electric Code (NEC).
- F. Telecommunications Industry Association / Electronic Industries Association (TIA/EIA):
 - 1. 568B: Commercial Building Telecommunications Cabling Standards.
 - 2. 569B: Commercial Building Standard for Telecommunications Pathways and Spaces.
- G. Underwriters Laboratories Inc. (UL).

1.03 DEFINITIONS

- A. The following definitions may be used throughout this section and subsections:
 - 1. CTC: Communications termination cabinet
 - 2. HMI: Human machine interface
 - 3. LAN: Local area network.
 - 4. LCP: Local control panel.
 - 5. IP: Internet Protocol

6. MIMO: Multiple-input and multiple-output
7. OIT: Operator interface terminal
8. OSP: Outside Plant
9. PC: Personal computer
10. PLC: Programmable logic controller
11. PoE: Power over Ethernet
12. SCADA: Supervisory control and data acquisition
13. SCS: Structured Cabling System
14. UPS: Uninterruptible power supply
15. VOIP: Voice over IP
16. WAN: Wide area network
17. WAP: Wireless Access Point

1.04 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 1. For each network cabinet supplied.
- B. Submit on product data for each type of product in accordance with Section 01 33 00.
- C. Submit network drawings for physical connections between all network hardware.
- D. Informational Submittals:
 1. Field quality-control reports.

1.05 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.06 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.
- B. Hardware and software to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of, equipment

furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

- C. Examine the Contract Documents and verify that network and communications equipment and software being provided is compatible with the requirements. Provide all necessary accessories for a complete and operable system.

1.07 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

1.08 PROJECT/SITE CONDITIONS

- A. Classification of Plant Areas:

- 1. Refer to Division 26.

1.09 WARRANTY

- A. The Contractor shall provide a three (3) year warranty on structured cabling systems. This includes all copper and fiber cabling, patch panels, patch cables and CTC assemblies (excluding UPS and other electronic devices).

PART 2 - PRODUCTS

2.01 GENERAL

- A. Refer to the requirements of Division 01.

- B. Selected Products:

- 1. Provide products and materials that are new and free from all defects.
 - 2. Products and materials called for on the drawings or in the specifications by trade names, manufacturer's name and catalogue reference are to be used as the basis for the bid submission.
 - 3. The design has been based on the use of the first named product where multiple products have been listed.

- C. Quality of Products:

- 1. All Products provided to be NEC and UL approved where applicable.
 - 2. If Products specified are not NEC and UL approved, obtain approval of the relevant State regulatory authority. Pay all applicable charges levied and make all modifications required for approval.

3. Refer to Division 01 of this specification for further information.

D. Uniformity of Manufacture:

1. Unless otherwise specifically called for in the specification, uniformity of manufacture to be maintained for similar products throughout the work.

E. Product Finishes:

1. Contractor to specify proposed finishes to be used for Engineer's review.

F. Use of Products During Construction:

1. Any equipment used for temporary or construction purposes is to be approved by the Engineer and in accordance with Division 01 of this specification. Clean and restore to "as new" condition all equipment prior to the time of substantial completion.

2.02 NETWORK SWITCHES

A. Manufacturers:

1. Within NET-0000-1, NET-0000-3:
 - a. Rack mounted, 48-port.
 - b. Provided by the Owner for installation by the Contractor in Contractor-supplied enclosures.
2. Within new process control network cabinets:
 - a. Panel mounted.
 - b. Cisco, IE-4000-16T4G-E, or approved equal.

B. Panel Mounted Switches:

1. The switch shall be built for harsh environments and temperature ranges (40 degrees C to +75 degrees C)
2. Fanless, convection-cooled with no moving parts.
3. Hardened for vibration, shock and surge, and electrical noise immunity.
4. Switch shall have all Gigabit ports with 2 Gigabit Small Form-Factor Pluggable (SFP) uplinks plus 8x1 Gigabit copper RJ45 downlink ports in a small form-factor base system.

5. Expandable to 26 ports of Gigabit Ethernet by attaching one of 7 compatible modules (copper, PoE, fiber options).
6. Supports multiple rings and redundant ring topologies for new network configurations.
7. Cisco Network Essentials operating system.
8. Redundant 24VDC Power Supplies.
9. Device management with web user interface, over-the-air access via Bluetooth and Command-Line Interface (CLI).
10. All fiber connections shall occur at the managed switch level utilizing SFP ports and modules

C. Switch Accessories:

1. Small Form Pluggable (SFP) modules for switches:
 - a. For 10Gbps fiber links, provide the Cisco SFP-10G-LR (for rack-mount switches) and the Cisco SFP-10G-LRX (for industrial switches).
 - b. For 1Gbps fiber links, provide the Cisco GLC-LH-SM (for rack-mounted switches) and the Cisco GLC-LH-SMD (for industrial switches).
 - c. For 1Gbps copper links, provide the Cisco GLC-T (for rack-mounted switches) and the Cisco GLC-TE (for industrial switches).

2.03 NETWORK CABINETS

- A. Refer to Section 27 11 16 “Communications Racks, Frames, and Enclosures”.

2.04 NETWORK CABINETS HVAC EQUIPMENT

- A. All network cabinets shall be properly designed to maintain the inner temperatures of the enclosure within the 60 to 80 degrees F.
- B. Any HVAC equipment shall maintain the NEMA rating of the network cabinet assembly.
- C. Preferably, fans, air-to-air exchangers and AC units are mounted on the top of each network cabinet in unconditioned areas.

2.05 FIBER PATCH PANELS

- A. Provide 19 inch rack-mount fiber optic patch panels for network cabinets and wall-mount patch panels for industrial control panels.

- B. Provide patch panel adapter plates with duplex LC connectors for single mode fiber. Each plate shall accommodate six duplex connectors.
- C. Ensure that the number of fiber ports is as required per the network architecture diagram drawing.
- D. The patch panel shall provide protection for all fiber terminations and cable strain relief. The patch panel shall protect and conceal patch cord connections.
- E. Fiber patch panels shall be the Panduit FMD series for 19 inch racks and the FWME series for wall-mounted panels or approved equal.

2.06 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. Each network cabinet shall have a 1500VA UPS installed in it for surge protection and battery backup of critical network equipment. The UPS shall be 19 inch rack mountable and shall be mounted with sliding rails where possible. The UPS shall be a double-conversion system.
- B. Each UPS shall be capable of running the connected load for a minimum of 30 minutes.
- C. UPS Electrical Input Specifications
 - 1. Nominal Voltage: 120VAC
 - 2. Voltage Range: 80-144VAC
 - 3. Input Power Factor: > 0.95
 - 4. Frequency: 60 Hertz +/- 3 Hertz.
- D. UPS Electrical Output Specifications
 - 1. Voltage Regulation: +/- 3 percent of Nominal
 - 2. Efficiency: > 85 percent
 - 3. Frequency Regulation: +/- 3 Hertz on utility, +/- 1 Hertz on battery
- E. UPS Communications Specifications:
 - 1. A USB port shall be available for monitoring and configuring the UPS. An appropriate cable shall be supplied to connect to the UPS with a PC.
 - 2. An Ethernet port shall be available with the ability to monitor the UPS utilizing the SNMP protocol.

F. UPS Battery Specifications:

1. All batteries shall be sealed, lead-acid batteries and shall be maintenance free. Batteries shall be hot-swappable. The UPS will indicate when the battery is weak and needs to be replaced.
2. The UPS shall be able to accept additional battery modules to extend the runtime of the UPS.

G. Acceptable Manufacturers:

1. Eaton Tripp Lite.
2. Eaton 9PX.

H. Each UPS shall have a Liebert Micropod bypass switch.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Refer to the requirements of Division 01.

3.02 COORDINATION WITH OTHER DIVISIONS

- A. Examine the drawings and specifications of all divisions and become fully familiar with the work. Before commencing work, obtain a ruling from the Engineer on any conflicting issues between divisions. No compensation will be made for any costs arising from conflict not identified before work has commenced.
- B. Coordinate the work to be performed under this section of the specification with all divisions installing equipment to ensure that there are no conflicts.
- C. Lay out the work and equipment with due regard to architectural, structural, and mechanical features. Architectural and structural drawings take precedence over electrical drawings regarding locations of walls, doors, and equipment.
- D. Examine previously constructed work and notify the Engineer of any conditions which prejudice the proper completion of this work.

3.03 PRODUCT HANDLING

- A. Use all means necessary to protect the products included in this division before, during and after installation, and to protect products and installed work of all other trades.
- B. Any damage to the products and/or installed work shall be repaired or replaced to the approval of the Engineer by the Contractor at no additional cost to the Owner.

- C. Remove advertising labels from all products installed that have such labels attached. Identification, NEC, and UL labels are not to be removed.
- D. Remove dirt, rubbish, grease, etc. resulting from work performed under this section of the contract from all surfaces.

3.04 NETWORK PROGRAMMING

- A. Provide configuration and programming for all network switches and PLCs for integration with the existing City-wide SCADA network. Programming for vendor supplied network switches shall be performed by the vendor.
- B. Refer to specification Section 40 68 00 for additional requirements and details.

3.05 INSTALLATION

- A. Refer to the requirements of Division 01 for additional requirements.
- B. The Contractor shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies which it provides. The Contractor shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it provides.
- C. All components of the SCS shall be the installation responsibility of the Contractor unless specifically noted otherwise. After the installation of the SCS is completed, the installation shall be inspected jointly by the Contractor and the Equipment Manufacturer's representatives. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the Engineer. The certification shall state that all cabling and terminations have been inspected and are installed in accordance with the manufacturer's guidelines.
- D. Miscellaneous Equipment. The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wire molding, and support hardware, etc., necessary to facilitate the installation of the network cabinets within the SCS. All metal fasteners and straps in corrosive or wet areas shall be 316SS.
- E. Special Equipment and Tools. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the SCS. This may include, but is not limited to, tools for terminating cables, testing and splicing equipment for copper/fiber cables, communication devices, jack stands for cable reels, or cable wrenches.
- F. Penetrations of Walls, Floors, and Ceilings. The Contractor shall make no penetration of existing walls, floors and/or ceilings without the prior consent of the Owner. Where penetrations through acoustical walls, fire-rated doors or other walls for cableways are to be installed, such penetrations shall be sealed by the Contractor in compliance with applicable code requirements.

- G. The network cabinets and all components of the system shall be installed in a neat, workmanlike manner. Wiring color codes shall be strictly observed and terminations shall be uniform throughout the system. Identification markings and systems shall be uniform. TIA/EIA 568B wiring codes as shown on the drawings shall standardize all SCS wiring. The CTC shall be level and plumb.

3.06 COMMISSIONING

- A. Commissioning of network and communication systems is to include but not be limited to the following:
 - 1. Verify installation of components, power and network connections.
 - 2. Supervise network cable testing.

3.07 TRAINING

- A. Provide training, described in detail in Section 01 78 25, as required by the plant's personnel to become fully competent in the proper operation and maintenance of all network and communication equipment described under this section of the specifications.

3.08 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 67 00

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide control system equipment panels and racks as indicated and in compliance with Contract Documents.
- B. Local control stations shall be supplied to house local control switches, push buttons and indicator lights associated with field devices (valves, drives, etc.) as indicated on the P&ID drawings. The control stations shall be located in close proximity to their associated devices. Where a group of devices are located within close proximity to each other, the local controls may be combined into a single common local control panel. Line of site must be maintained between all devices and the respective local controls.

1.02 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.

1.03 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.04 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.05 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Unless otherwise specified, provide outside finishes on all enclosures in ANSI 61 Grey.
- B. The enclosures must be suitable for carrying the weight of the equipment mounted inside the panel and on the doors without any warpage.
- C. Control panels and enclosures shall be UL508A listed.

2.02 ENCLOSURES

- A. Provide NEMA Type 1A gasketed enclosures in ordinary locations.
- B. Provide NEMA Type 4X (Type 316 stainless steel) enclosures for Category 1 and 2 wet and corrosive locations and all outdoor locations. Where installed outside, provide enclosures with a sunshield cover to completely protect and enclose the control panel.
- C. Enclosures located in electrically hazardous classified areas shall bear appropriate hazardous area ratings based on the area classifications identified by Division 26.
- D. Enclosures for mounting field control indicator lamps and switches in unclassified areas to be heavy duty die cast enclosures.

2.03 PANEL ENCLOSURES

- A. Fabricate panel enclosures from minimum 11 gauge steel panels complete with necessary stiffening to form a rigid free-standing line up. The structures must be suitable for carrying the weight of the equipment mounted inside the panel and on the doors. Provide removable top and bottom cable entry plates.
- B. Minimum enclosure outer dimensions shall be 60" high by 48" wide by 12" deep. PLC-0000-1 shall be floor mounted on a 4" housekeeping concrete pad. RIO-0000-1 and PLC-0000-2 shall be wall-mounted.
- C. Provide panels with front access only. Doors shall be pad lockable and fitted with 3 point heavy duty latching assemblies. Provide a continuous piano hinge and a pneumatic hold open device or door stop kit on each door.
- D. Finish the interior of the enclosure with white paint. Provide a switched light fixture and 120 VAC duplex convenience receptacle inside the enclosure.

2.04 MARSHALING, CONTROL, AND PLC PANELS

- A. Supply, fabricate, checkout, layout, document and deliver to Site fully equipped and functional panels.
- B. Supply all components contained on or within the panels fully wired under this Section of the Specification.
- C. The selection of all accessories, materials and methods for fabrication not covered by this Specification, but which are necessary to complete the fabrication of the control panels, is the responsibility of the panel fabricator.
- D. Fans and filters shall be installed to pressurize all control panels in non-hazardous areas thus discouraging dust accumulation and providing air purging for temperature and corrosion control.

- E. Marshalling and control panels shall be adequately sized to facilitate a professional, uncluttered arrangement. Provide adequate internal and external space to accommodate a 20 percent increase in each type of component used.
- F. Marshalling, control, and PLC layouts and wiring diagrams are to be provided by the Contractor as Shop Drawings.

2.05 WIRING AND ACCESSORIES

- A. Provide wiring inside the panels according to the following Specifications:
 - 1. Control wiring to be a minimum of #16 AWG tinned stranded copper; insulation rated at 600 V.
 - 2. Wiring for power distribution shall be a minimum of #14 AWG tinned stranded copper; insulation rated at 600 V.
 - 3. Install cables in accordance with the requirements of Division 26.
- B. Tag each wire at both ends with a heat shrink sleeve that is machine printed. Allow approximately 1 inch of wire insulation between the tag and the bare wire.
- C. Wiring systems with different voltage levels or types shall be suitably segregated within the panel, according to relevant electrical codes.
 - 1. Proper insulation and separation between 120VAC/24VDC and 480VAC circuits, equipment, and wiring shall be provided to maximize personnel safety.
- D. Run all wiring in enclosed plastic wire troughs such as Panduit. Size all wire troughs so that the total cross sectional area of the insulated wire and cable does not exceed 40 percent of the cross sectional area of the wire way.
- E. Provide a minimum clearance of 2 inches between wire trough and any point of wire termination.
- F. Terminate all wiring, incoming and outgoing, at dedicated terminal strips mounted inside the panels. Identify each terminal strip with a terminal strip number, defined as follows:
 - 1. Wire identification to use the connected field device tag name with the wire's corresponding end device terminal number appended to it.
 - 2. Identify every joint and/or terminal of the above wire run with the same identifier until the wire meets another tagged device, at which point the wire identifier will change to use the new device name and terminal number.
 - 3. Identify spare wires by using the cable tag, wire number and an “-SP” suffix.

4. Arrange wiring on terminal blocks such that all internal panel wiring terminates on the inboard side of the terminal blocks and all external wiring terminates on the outboard side.
- G. Provide a 120 VAC panel power distribution system and 24 VDC and other DC power distribution systems as required in each panel to accommodate all instrumentation systems fed from the panel. Provide a thermal magnetic circuit breaker and surge suppression on each main power circuit and a fused terminal block for each branched circuit off the main.
- H. Provide disconnect type terminal blocks to isolate field wiring that is powered sourced from the panel. Provide a dedicated fused disconnect type terminal block to isolate each individual PLC input and output.
- I. All PLC discrete inputs and outputs shall be provided with interposing relays. Interposing relays shall be as specified in Section 40 78 00 and shall be used to isolate all field wiring from PLC terminals.
- J. Provide sufficient terminals so that not more than two wires are connected under the same terminal. Provide 20 percent spare terminal capacity at each terminal block assembly.
- K. Terminals shall be color coded as follows:
 1. Grey: Positive 24 VDC.
 2. Grey: Analog signal plus.
 3. Grey: Analog signal common and VAC neutral.
 4. Grey: 120 VAC.
 5. Green: Ground.
- L. Surge suppression shall be provided on all analog signals. Refer to Section 40 78 00 for specific equipment and requirements.
- M. Provide nameplates for each device on or within the panels and enclosures. Nameplates shall be white laminated plastic with black lettering, a minimum of 1 inch x 3 inches in size with up to three lines of 0.25 inch lettering. Securely fasten nameplates in and situate them in a visible location. All nameplates shall include the prefix P25-.

2.06 INTRINSICALLY SAFE BARRIERS

- A. Intrinsically safe relays and devices shall be provided for all signals that originate, terminate, or otherwise interface in, hazardous and classified areas. Refer to Section 40 78 00 for specific equipment and requirements.

2.07 PANEL POWER SUPPLY

- A. Each PLC panel, or control panel, shall have a 1500VA UPS installed in it for surge protection and battery backup of critical equipment. When a PLC is co-located with network equipment, the UPS shall be sized to carry all equipment. The UPS shall be 19-inch rack mountable and shall be mounted with sliding rails where possible. The UPS shall be a double-conversion system.
- B. Each UPS shall be capable of running the connected load for a minimum of 30 minutes.
- C. UPS Electrical Input Specifications
 - 1. Nominal Voltage: 120VAC
 - 2. Voltage Range: 80-144VAC
 - 3. Input Power Factor: > 0.95
 - 4. Frequency: 60 Hertz +/- 3 Hertz.
- D. UPS Electrical Output Specifications
 - 1. Voltage Regulation: +/- 3 percent of Nominal
 - 2. Efficiency: > 85 percent
 - 3. Frequency Regulation: +/- 3 Hertz on utility, +/- 1 Hertz on battery
- E. UPS Communications Specifications:
 - 1. A USB port shall be available for monitoring and configuring the UPS. An appropriate cable shall be supplied to connect to the UPS with a PC.
 - 2. An Ethernet port shall be available with the ability to monitor the UPS utilizing the SNMP protocol.
- F. UPS Battery Specifications:
 - 1. All batteries shall be sealed, lead-acid batteries and shall be maintenance free. Batteries shall be hot-swappable. The UPS will indicate when the battery is weak and needs to be replaced.
 - 2. The UPS shall be able to accept additional battery modules to extend the runtime of the UPS.
- G. Acceptable Manufacturers:
 - 1. Powerware 5 or 9 Series.

2. Liebert GTX Series.

3. APC Smart-UPS Series.

H. Each UPS shall have a Liebert Micropod bypass switch and relay outputs to allow monitoring of hardwired I/O points.

2.08 PANEL GROUNDING

A. Provide a ground system for the instrumentation circuits, isolated from the main power system ground to each marshaling panel.

B. Provide grounding lugs for each panel, suitable for termination of up to #2 AWG copper grounding conductor.

C. Provide in each marshaling panel an isolated grounding bus bar 0.25 x 1 x 24 inch, equipped with necessary lugs for accepting two (2) #2 AWG grounding conductors.

D. Firmly bond all panel-mounted devices on or within the panels to ground. Provide supplementary bonding conductors for backpanels and doors. Attach a separate bonding conductor to all devices that are not firmly fastened to the panels with screws for such devices as case mounted instruments, meters, etc.

PART 3 - EXECUTION

3.01 MOUNTING HEIGHTS

A. Unless otherwise specified or a conflict exists, mount all control panels:

1. 48 inches or taller such that the top of the control panel is at 78 inches above the finished floor.

2. Less than 48 inches such that the panel is centered at 48 inches above the finished floor.

3.02 CORROSION INHIBITION

A. All control panels shall be provided with corrosion inhibiting vapor capsules.

3.03 CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 68 00

PROCESS CONTROL SOFTWARE

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide Process Control Software as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging
 - 2. S18.2: Alarm Management
 - 3. S99: Control System Cyber Security
 - 4. 101: Human-Machine Interfaces

1.03 DEFINITIONS:

- A. FAT: Factory acceptance test
- B. HMI: Human machine interface
- C. I&C: Instrumentation and control for process systems
- D. IS: Instrumentation supplier
- E. LAN: Local area network
- F. LCP: Local control panel
- G. NC: Normally closed
- H. NO: Normally open
- I. OIT: Operator interface terminal
- J. OSI: Owner's System Integrator
- K. PC: Personal computer
- L. PID: Control action, proportional plus integral plus derivative

- M. PLC: Programmable logic controller
- N. P&ID: Process and instrumentation diagram
- O. RIO: Remote input/output
- P. SCADA: Supervisory control and data acquisition
- Q. VCP: Vendor control panel

1.04 SUBMITTALS:

- A. Submittals shall meet the requirements of Section 01 33 00.
- B. A minimum of four weeks prior to factory acceptance testing, submit programming files for review.
- C. After program development but prior to start-up and commissioning, provide a list of system points for alarming for review by the Owner and Engineer.
- D. After satisfactory review of all hardware submittals by the Engineer, the I&C Subcontractor shall submit a copy of all color display screens reflecting all process areas, including vendor sub-systems. This submittal shall include the following for each process area:
 - 1. System Graphics.
 - 2. Trends and data graphs.
 - 3. Alphanumeric displays.
 - 4. Alarm system display.
 - 5. Each graphical display shall have a unique title:
 - a. Clearly identify where process data is to be displayed using simulated data or placeholder variables with a reference list.
 - b. All equipment and instruments shall be identified with tag number as shown on the Contract Drawings. Their operation change shall be described therein including:
 - (1) Start/Stop
 - (2) Open/Close
 - (3) In Hand/Remote
 - (4) Other changes in state or position as required.

6. All standard and customizable reports for all processes including vendor sub-systems.
 - a. Clearly label all process data using simulated data or placeholder variables with a reference list.

E. Operations Manual

1. The I&C Subcontractor shall prepare and submit an Operations Manual. The manual shall be provided in both electronic and hard copy format. The electronic manual shall be provided in PDF format with appropriate section bookmarks. The hard copy format shall be provided in a three-ring binder with appropriate section bookmarks. The manual shall include but not be limited to the following:
 - a. Table of Contents
 - b. All Operator Interface Displays:
 - (1) Process Flow Graphics
 - (2) Trending
 - (3) Reporting
 - (4) Alarms
 - c. A summary list of all operator inputs including operator-adjustable setpoints for all process areas including vendor sub-systems.
 - d. Instructions for printing screens, reports, and trends.
 - e. Summary of security clearances and where they apply throughout the facility.
 - f. Process Flow Diagram and Network Architecture Diagram.
2. A copy of this manual shall be provided to every operator during training. Training shall encompass a review of the manual and the contents therein.

F. All the following shall be submitted and approved prior to commissioning activities:

1. Program manuals supplied by manufactures with software packages.
2. All software programs for all supplied PLCs including vendor-supplied subsystems.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

- B. The I&C Subcontractor shall schedule the following meetings at the indicated milestones, at a minimum, with the General Contractor, Engineer, and Owner:
 - 1. Graphics, Alarms, and Reports Initial Submittal
 - 2. Graphics, Alarms, and Reports Revision Submittal
 - 3. Accepted Graphics, Alarms, and Reports prior to I&C Subcontractor mobilizing to the site for any field programming activities.
- C. The I&C Subcontractor shall provide upon request a formal documented quality assurance and quality control program applying to all engineering, fabrication, construction, programming, start-up, and commissioning of the process control software to be provided herein.
- D. Refer to Section 40 61 21 for process control system testing requirements.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

1.07 SYSTEM DESCRIPTION

- A. Provo City Water Resources has standardized around Rockwell Automation Allen-Bradley PLC hardware, RSLogix software, the Rockwell Automation PanelView Plus hardware, and Rockwell Automation FactoryTalk HMI software. If a piece of equipment has been approved and is being supplied with PLC hardware, OIT hardware or HMI software that is different than these standards, the Contractor shall provide all licenses associated with the hardware or software. These licenses shall be in the Owner's name and shall provide full functionality with the equipment or software that has been provided.
- B. The SCADA system equipment nodes to be provided by the I&C Subcontractor under this Contract includes field PLC hardware and Operator Workstations (OWS). Process Control System Software required for complete operation of all nodes and integration with SCADA network shall be provided. Refer to the Network Architecture Diagram 00-I601 for additional details.
- C. SCADA Interfacing Node Types:
 - 1. Field PLC Hardware: Provide field PLC hardware to interface with field instrumentation, motor controllers, rotating machines, etc.
 - 2. Operator Workstation: Provide all graphic display and related software for interacting with the SCADA system data. OWS shall be provided with software for the viewing of real time SCADA system data, alarms, etc. They shall be equipped with drivers for interfacing with all existing and proposed field devices, historical data, and provide data for the existing Historian located off-site. SCADA displays

shall operate on data maintained by the OWS in the Administration Building. Capabilities to include but not be limited to the following:

- a. All process systems displays including vendor sub-systems.
- b. Control of all necessary process variables and inputs including vendor sub-systems.
- c. Historical and real-time trend data for all process systems and vendor sub-systems.
- d. Current and historical alarm data.
- e. System utilities.

PART 2 - PRODUCTS

2.01 SCADA HMI APPLICATION

- A. Rockwell Automation FactoryTalk View SE
- B. No equal.

2.02 WORKSTATIONS

- A. Workstations shall be supplied by the Owner. The I&C Subcontractor shall be responsible for providing all software listed herein and configuring the workstations as required for a fully functional and operational system.
- B. The following software shall be provided on the specific operator workstations:
 - 1. Administration Building Control Room Normal and Standby Operator Workstations
 - a. Windows 10 Operating System
 - b. FactoryTalk View SE Client
 - c. FactoryTalk Historian Client
 - d. Rockwell Automation Plant PAX Virtual Machines
 - e. Plant FactoryTalk View SE Data & I/O Virtual Server
 - f. FactoryTalk View SE Client.
 - g. Virtual Domain Controller
 - h. Kepware

- i. RS Linx
- 2. Administration Building Plant Manager and Operator Workstations
 - a. Windows 10 Operating System
 - b. FactoryTalk View SE Client
 - c. FactoryTalk Historian Client

2.03 GENERAL PROGRAMMING REQUIREMENTS:

- A. SCADA system software to be used for application software development, existing system expansion, and real time operation of the SCADA system.
- B. Software provided under this Contract represents a complete and operating control software system. Achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.
- C. The software listed in this specification is not intended to represent the comprehensive list of software necessary to implement the functional and operation systems and requirements of the Contract Documents. Provide all ancillary necessary supplemental components, drivers, utility software, and application software required to meet the requirements of the Contract Documents.
- D. Control Loops. A control loop is a single piece of equipment or a group of equipment that performs a specific function. Each control loop will have an associated loop number and description. Process Equipment and programming shall be divided into loops based upon their corresponding function. This allows the process to be neatly broken down into parts that are simple and logical. Multiple pieces of equipment should not have the same loop number.
- E. Loop Numbers. Each control loop shall be assigned a unique number to set itself apart from all other loops.
- F. Control Strategies. Each control loop shall have or be part of an associated control strategy. The control strategy is used to describe the function of each control loop in detail. Refer to Section 40 61 96 for the control strategies for this project.
- G. Equipment and Instrumentation Tagging:
 - 1. Equipment and instrumentation shall be tagged as shown on the P&IDs in the Contract Drawings. Instrumentation tagging follows the ISA-5.1-2009 standard where the tag has a functional identification letter code and then the loop number. The functional identification letter code should follow what is shown on P&ID drawing 00-X602.

2. The functional identification of an instrument or its functional equivalent consists of letters from the table on 00-X602 and includes one first-letter (designating the measured or initiating variable) and one or more succeeding letters (identifying the functions performed).
 3. The functional identification of an instrument is made according to the function and not according to the construction. Thus, a differential pressure transmitter used for flow measurement would be identified by FT and not PDT.
 4. The succeeding letters of the functional identification designate one or more readout or passive functions and/or output functions. A modifying letter may be used, if required, in addition to one or more other succeeding letters. Modifying letters may modify either a first letter or succeeding letters, as applicable. Thus, TDAL contains two modifiers. The letter D changes the measured value T into a new variable, "differential temperature." The letter L restricts the readout function A, alarm, to represent a low alarm only.
 5. The sequence of identification letters begins with a first letter selected according to the table below. Readout or passive functional letters follow in any order, and output functional letters follow these in any sequence, except that output letter C (control) precedes output letter V (valve), e.g., PCV, a self-actuated control valve. However, modifying letters, if used, are interposed so that they are placed immediately following the letters they modify.
 6. The number of functional letters grouped for one instrument should be kept to a minimum according to the judgment of the user. The total number of letters within one group should not exceed four. All functional letters groups shall be reviewed by the Owner and Engineer for approval.
 7. Refer to drawing 00-X602 for specific letter combinations that are not defined in ISA-5.1-2009 Table 4.1.
- H. Process and Instrumentation Diagrams (P&IDs). P&IDs for the project are found in the Contract Drawings and should be used as a basis for developing the programming for the system.
- 2.04 PLC PROGRAMMING REQUIREMENTS:
- A. Vendor systems with PLCs shall be programmed by the vendor and factory tested prior to delivery to the site. Vendors shall become familiar with the requirements of this section.
 - B. Contractor furnished PLCs (not as part of a vendor package) shall be programmed by I&C Subcontractor.
 - C. PLC Configuration. Each PLC shall be programmed with its own project within Unity. The project name shall be the name of the PLC as shown on the Contract Documents.

1. PLC Hardware Configuration. The PLC Hardware Configuration shall be setup by showing the modules that have been designed for each slot of each rack. The arrangement of the modules shall be in an orderly fashion with space for future expansion. Redundant controllers consist of two identical racks with redundant power supplies, processors and Ethernet communication modules.
2. Additional racks shall be installed when additional I/O modules are required.

2.05 OIT PROGRAMMING REQUIREMENTS:

- A. Operator Interface Terminals (OITs) shall be provided at the machine level where a local interface is required in the process area. When an OIT is required it shall be programmed as follows:
 1. Develop a main page with system status, alarm status and navigation. The main page shall include the date and time and have a button to allow the operator to update the date and time.
 2. The OIT shall have user security with viewer, operator and supervisor usernames and passwords. When logged in as viewer (default), the user may see all the pages but does not have any control. When logged in as operator, the user may be able to control the system and change set points that are commonly changed. When logged in as supervisor, the user may control the system and change all set points.
 3. The OIT shall have an alarm page that shows current alarms. Alarms may be acknowledged and reset from this screen. The screen shall be synced with the plant HMI system so that alarm acknowledgement may occur at either location and reflect the acknowledgement on both systems. A separate page shall show an alarm history.
 4. The OIT shall have additional pages for the process and equipment for which the OIT is monitoring and controlling.
 5. Fonts – The font shall typically be Arial size 13 except for titles that may have larger font.

2.06 HMI PROGRAMMING REQUIREMENTS:

- A. All HMI programming will be performed by the I&C Subcontractor.
- B. General. The SCADA system shall be developed based upon the Rockwell Automation FactoryTalk View SE software platform. The core of the system shall consist of two proposed main and backup workstations that shall run the SCADA system for the facility. These workstations shall host the database, historian, and I/O drivers for gathering the tags from the PLC's throughout the facility. The workstations shall also act as SCADA historians, which collect data from selected tags and records that data to a historical database. That data is then used for generating trends and reports. All SCADA clients are launched from a network connection established to offsite SCADA servers.

C. Network Configuration.

1. Only workstations connected to the SCADA network shall be allowed to launch SCADA clients. The SCADA program shall be located in the redundant Control Room Operator Work Stations in the Control Room of the Administration Building and provided with dedicated, redundant connections between each other. The SCADA network IP address assignment should be coordinated with the Owner and Engineer for proposed PLCs, vendor-supplied subsystem PLCs, the new operator workstation, and additional supervisory layer SCADA hardware.

D. Redundancy Configuration.

1. Configure the workstations such that one shall operate as a main workstation and one shall operate as a fully functional standby workstation as indicated. If the main workstation goes down or is otherwise disconnected the standby shall automatically take over. Then when the main workstation is back online it will take over again as the main.

E. SCADA System Security.

1. Each workstation setup shall have security installed to prevent unauthorized users to access the system. The system shall have an audit log setup that records all user transactions to SQL Server. Security shall be setup so that users may be granted access to areas with varying security levels. coordinate with the Owner for security clearance levels, range of permissions, and inactivity log-out timers.

F. Alarm Configuration.

1. The SCADA System shall be setup to provide an alarm alerting system that alerts and displays to operators any new or acknowledged alarms. In addition, an alarm history shall allow the operator to see alarms from any chosen previous date and time. Alarms shall be categorized by area or process like the above described security areas.

G. I/O Drivers. Workstations shall be provided with applicable software for connecting to devices such as PLC's to monitor and control those devices. Each device shall be strategically named and shall be setup for tag name queries. Associated with each PLC shall be a scan class for that device that determines how often the device is polled for data.

H. Tag Database Development:

1. General. SCADA System tags shall be well organized into folders for each process control loop. Parent folders shall contain the facility and process area, location or PLC. Often folders are preceded by a number so that the folders are in process order. Each control loop folder should contain all the tags necessary to monitor and control that loop.

2. Data Types. So that similar tags are consistently the same from one loop to another, Data Types shall be utilized. A Data Type is a tag structure that may consist of one or more individual tags. They will include all the necessary tags from the DFB plus additional internal tags that assist in the monitoring and control of the control loop.
3. Client Tags. Client tags are used for functions that are unique to each FactoryTalk client. Uses include custom user settings, screen settings and security settings.
4. System Tags. System tags are used to show information about the SCADA software. Use these tags to show status of the system, including communications to devices, redundancy health, system date and time, system performance, database connectivity and alarm status.

I. SCADA Screens

1. Development:
 - a. To maintain consistency throughout the facility's SCADA screens, new screens shall be developed using templates from the existing screens. Symbols for blocks such as pumps, valves, pipes, process equipment, discrete displays, numeric displays, control buttons, numeric set points, etc. shall match the existing screens. A copy of the existing system screens can be provided upon request to the Owner.
2. Windows:
 - a. Top Menu – Across the top of the screen shall be a top menu. This menu is always visible to the operator.
 - b. Overview Screen – When the FactoryTalk View Client is launched, and the operator logs in for the first time, the Menu, Navigation Tree and main Overview Screen should always be displayed.
 - c. Standard Windows:
 - (1) Alarms – The alarms screen is where the operator goes to look at current and past alarms. The screen should be capable of indicating active alarms, alarm history, disabled alarms, suppressed alarms, and equipment taken out of service:
 - (2) Trending – The trending screen allows operators to view custom and/or saved trends for the facility.
 - (3) Communications – The communications screen allows operators to view the architecture of the SCADA system. All devices that are connected to the SCADA system with a communications link (typically an Ethernet link) shall be shown on this screen. Status of the communication of each device is shown and alarms are triggered if

communications are lost with each of the devices. PLC's shall show their current state (running, stopped or faulted) and system clock.

- (4) Logs – The logs screen is a location for operators to view various logs that are being kept through the SCADA software as well as give the operator the ability to enter their own logs. The logs screen shall have a set of tabs for each log that has been configured.
 - (5) Reports – The Reports screen is where the operator goes to setup, view, print and/or obtain data related to the facility's process.
- d. Project Windows – The project windows allow the operator to see how each control loop within each process of the facility is functioning and provides access to control loop popups which allow the operator to make control and set point changes. The screens shall be designed in a 2-dimensional process flow diagram manner. When developing project windows, the programmer shall hold screen development workshops with the Owner and Engineer. In the initial workshop the programmer shall present his or her ideas on how the project windows should look and obtain input from the Owner and Engineer. Then the programmer will develop the first draft of all project windows as which point a subsequent workshop will be held and the screens presented. Final modifications will be implemented and then a final workshop should be held. In the final workshop the screens should be presented in a fully functional FactoryTalk client with simulated data.
 - e. Popups – The programmer shall develop popups for the project so that monitoring and control of each control loop throughout the system is properly achieved. Popups may be unique or may be templates that are interchangeable. Popups shall follow the District's HMI Standards as shown in Attachment A to this specification section.

PART 3 - EXECUTION

3.01 PREPARATION

- A. The Contractor is responsible for all factory testing in accordance with Section 40 61 13 and Section 40 61 21.

3.02 INSTALLATION:

- A. Provide in accordance with Section 40 61 13.

3.03 FIELD TESTING:

- A. Provide in accordance with Section 40 61 21.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 70 00

INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide Instrumentation for Process Systems as specified in this section and in compliance with related detailed instrumentation specification sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and Testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Sustainable Design Submittals.

2. Prepare and submit Instrument Data Sheets for each instrument supplied for this project in accordance with the ISA S20 standard. Clearly indicate all pertinent data for the respective instrument on the data sheets and clearly indicate any deviations from specified requirements. The completed Instrument Data Sheets shall be submitted together with and form an integral part of the instrumentation shop drawings specified in this division.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sustainability Standards Certifications.

1.06 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10
- B. All instrumentation shall be stored according to the manufacturer's instructions.

1.07 WARRANTY

- A. As specified in Section 01 78 36.
- B. Instruments shall be provided with a minimum 1-year manufacturer's warranty.
- C. In the event a component or instrument fails to perform as specified or is proven defective during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost to the Owner.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION LIST

- A. The table provided in this section is an itemized list of instrumentation to be supplied for this project. The instrumentation list provides detailed information for the tagged instrumentation devices shown on the Piping & Instrumentation Diagrams.
- B. The Instrumentation List also provides references to the P&ID drawing, instrumentation specification section, responsible party for supplying, standard details, and location drawings.

PART 3 - EXECUTION

3.01 INSTRUMENT LIST

- A. Contractor shall update the Instrument List to reflect all changes in the work, and as required based on shop drawings that have been returned from the Engineer with a “Reviewed Only” or “Reviewed as Noted” status.
- B. The as-constructed Instrument List shall be included in the O&M manual submittal.

3.02 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION



PROVO RIVER WATER TREATMENT PLANT
PROVO CITY WATER RESOURCES
PROVO, UT

Instrument List

AECOM PROJECT NO.: 60670884
ISSUE DATE: 06/28/2023
REVISION: ISSUED FOR BID - REV 1

Tag	Drawing Number	Description	Unit Type Designator	Furnished By	Installation Detail	Location Drawing	Spec No.	Notes
P25-AIT-0102-1	01-X601	N/A	AIT	N/A	N/A	N/A	N/A	Future Instrument Provided by Others
P25-LIT-0102-1	01-X601	Diversion Box Level Indicating Transmitter	LIT	Contractor	I001	01-D101	40 72 00	Refer to 40 72 00 Schedule
P25-FE-0102-2	01-X601	Irrigation Pump Discharge Flow Element	FE	Contractor	I003	01-D101	40 73 00	Refer to 40 73 00 Schedule
P25-FIT-0102-2	01-X601	Irrigation Pump Discharge Flow Indicating Transmitter	FIT	Contractor	I003	01-D101	40 73 00	Refer to 40 73 00 Schedule
P25-ZSO-0102-1A	01-X601	Coagulant Injection Vault Hatch Intrusion Switch	ZSO	Contractor	N/A	01-D101	26 05 90	
P25-ZSO-0102-1B	01-X601	Coagulant Injection Vault Hatch Intrusion Switch	ZSO	Contractor	N/A	01-D101	26 05 90	
P25-LSHH-0102-1	01-X601	Coagulant Injection Vault Level Switch High High	LSHH	Contractor	N/A	01-D101	40 72 00	
P25-FIT-0303-1	10-X601	Raw Water Plant Inlet Flow Indicating Transmitter	FIT	Contractor	I003	10-D402	40 71 00	Refer to 40 71 00 Schedule
P25-FIT-0302-1	10-X601	Coagulant Flash Mix Pumps Discharge Header Flow Indicating Transmitter	FIT	Contractor	I003	10-D401	40 71 00	Refer to 40 71 00 Schedule
P25-FE-0303-1	10-X601	Raw Water Plant Inlet Flow Meter	FE	Contractor	I003	10-D402	40 72 00	Refer to 40 72 00 Schedule
P25-FE-0302-1	10-X601	Coagulant Flash Mix Pumps Discharge Header Flow Meter	FE	Contractor	I003	10-D401	40 71 00	Refer to 40 71 00 Schedule
P25-TSH-0302-6	10-X601	Coagulant Flash Mix Pump 2 Motor Temperature Switch	TSH	Vendor	N/A	10-D401	40 74 00	Refer to 40 74 00
P25-TSH-0302-5	10-X601	Coagulant Flash Mix Pump 1 Motor Temperature Switch	TSH	Vendor	N/A	10-D401	40 74 00	Refer to 40 74 00
P25-PIT-0303-1	10-X601	Raw Water Plant Inlet Pressure Indicating Transmitter	PIT	Contractor	I004	10-D402	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0302-6	10-X601	Coagulant Flash Mix Pump 2 Suction Pressure Switch Low	PSL	Contractor	I004	10-D401	40 73 00	Refer to 40 73 00 Schedules
P25-PSL-0302-5	10-X601	Coagulant Flash Mix Pump 1 Suction Pressure Switch Low	PSL	Contractor	I004	10-D401	40 73 00	Refer to 40 73 00 Schedules
P25-AIT-0303-1A	10-X601	Raw Water Plant Inlet Turbidity Analyzer	AIT	Contractor	N/A	10-D402	40 75 00	
P25-AIT-0303-1B	10-X601	Raw Water Plant Inlet pH Analyzer	AIT	Contractor	N/A	10-D402	40 75 00	
P25-PSL-0201-1	10-X602	UF Feed Pump 1 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0201-1	10-X602	UF Feed Pump 1 Motor Temperature Switch	TSH	Vendor	N/A	10-D410	40 74 00	
P25-DPSH-0201-2	10-X602	UF Strainer 1 Differential Pressure Switch High	DPSH	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0201-2A	10-X602	UF Strainer 1 Suction Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0201-2B	10-X602	UF Strainer 1 Discharge Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0203-1	10-X602	UF Feed Pump 3 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0203-1	10-X602	UF Feed Pump 3 Motor Temperature Switch	TSH	Vendor	N/A	10-D410	40 74 00	
P25-DPSH-0203-2	10-X602	UF Strainer 3 Differential Pressure Switch High	DPSH	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0203-2A	10-X602	UF Strainer 3 Suction Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0203-2B	10-X602	UF Strainer 3 Discharge Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0202-1	10-X602	UF Feed Pump 2 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0202-1	10-X602	UF Feed Pump 2 Motor Temperature Switch	TSH	Vendor	N/A	10-D413	40 74 00	
P25-DPSH-0202-2	10-X602	UF Strainer 2 Differential Pressure Switch High	DPSH	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0202-2A	10-X602	UF Strainer 2 Suction Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0202-2B	10-X602	UF Strainer 2 Discharge Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0207-2B	10-X603	UF Strainer 7 Discharge Pressure Indicator	PI	Contractor	I004	10-D409	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0207-2A	10-X603	UF Strainer 7 Suction Pressure Indicator	PI	Contractor	I004	10-D409	40 73 00	Refer to 40 73 00 Schedule
P25-DPSH-0207-2	10-X603	UF Strainer 7 Differential Pressure Switch High	DPSH	Contractor	I010	10-D409	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0207-1	10-X603	UF Feed Pump 7 Motor Temperature Switch	TSH	Vendor	N/A	10-D409	40 74 00	
P25-PSL-0204-1	10-X603	UF Feed Pump 4 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0204-1	10-X603	UF Feed Pump 4 Motor Temperature Switch	TSH	Vendor	N/A	10-D413	40 74 00	
P25-DPSH-0204-2	10-X603	UF Strainer 4 Differential Pressure Switch High	DPSH	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0204-2A	10-X603	UF Strainer 4 Suction Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0204-2B	10-X603	UF Strainer 4 Discharge Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule

P25-PSL-0205-1	10-X603	UF Feed Pump 5 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0205-1	10-X603	UF Feed Pump 5 Motor Temperature Switch	TSH	Vendor	N/A	10-D410	40 74 00	
P25-DPSH-0205-2	10-X603	UF Strainer 5 Differential Pressure Switch High	DPSH	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0205-2A	10-X603	UF Strainer 5 Suction Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0205-2B	10-X603	UF Strainer 5 Discharge Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0207-1	10-X603	UF Feed Pump 7 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0206-2A	10-X604	UF Strainer 6 Suction Pressure Indicator	PI	Contractor	I004	10-D409	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0206-2B	10-X604	UF Strainer 6 Discharge Pressure Indicator	PI	Contractor	I004	10-D409	40 73 00	Refer to 40 73 00 Schedule
P25-DPSH-0206-2	10-X604	UF Strainer 6 Differential Pressure Switch High	DPSH	Contractor	I010	10-D409	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0206-1	10-X604	UF Feed Pump 6 Motor Temperature Switch	TSH	Vendor	N/A	10-D409	40 74 00	
P25-PSL-0208-1	10-X604	UF Feed Pump 8 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0208-2A	10-X604	UF Strainer 8 Suction Pressure Indicator	PI	Contractor	I004	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0208-2B	10-X604	UF Strainer 8 Discharge Pressure Indicator	PI	Contractor	I004	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-DPSH-0208-2	10-X604	UF Strainer 8 Differential Pressure Switch High	DPSH	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0208-1	10-X604	UF Feed Pump 8 Motor Temperature Switch	TSH	Vendor	N/A	10-D413	40 74 00	
P25-PSL-0209-1	10-X604	UF Feed Pump 9 Suction Pressure Switch Low	PSL	Contractor	I004	10-D402	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0209-1	10-X604	UF Feed Pump 9 Motor Temperature Switch	TSH	Vendor	N/A	10-D410	40 74 00	
P25-DPSH-0209-2	10-X604	UF Strainer 9 Differential Pressure Switch High	DPSH	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0209-2A	10-X604	UF Strainer 9 Suction Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0209-2B	10-X604	UF Strainer 9 Discharge Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0206-1	10-X604	UF Feed Pump 6 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0213-2A	10-X605	UF Strainer 13 Suction Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0213-2B	10-X605	UF Strainer 13 Discharge Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-DPSH-0213-2	10-X605	UF Strainer 13 Differential Pressure Switch High	DPSH	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0213-1	10-X605	UF Feed Pump 13 Motor Temperature Switch	TSH	Vendor	N/A	10-D410	40 74 00	
P25-PSL-0210-1	10-X605	UF Feed Pump 10 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0210-1	10-X605	UF Feed Pump 10 Motor Temperature Switch	TSH	Vendor	N/A	10-D413	40 74 00	
P25-DPSH-0210-2	10-X605	UF Strainer 10 Differential Pressure Switch High	DPSH	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0210-2A	10-X605	UF Strainer 10 Suction Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0210-2B	10-X605	UF Strainer 10 Discharge Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0211-1	10-X605	UF Feed Pump 11 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0211-1	10-X605	UF Feed Pump 11 Motor Temperature Switch	TSH	Vendor	N/A	10-D410	40 74 00	
P25-DPSH-0211-2	10-X605	UF Strainer 11 Differential Pressure Switch High	DPSH	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0211-2A	10-X605	UF Strainer 11 Suction Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0211-2B	10-X605	UF Strainer 11 Discharge Pressure Indicator	PI	Contractor	I010	10-D410	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0213-1	10-X605	UF Feed Pump 13 Suction Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-DPSH-0212-2	10-X606	UF Strainer 12 Differential Pressure Switch High	DPSH	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0212-2B	10-X606	UF Strainer 12 Discharge Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0212-2A	10-X606	UF Strainer 12 Suction Pressure Indicator	PI	Contractor	I010	10-D413	40 73 00	Refer to 40 73 00 Schedule
P25-TSH-0212-1	10-X606	UF Feed Pump 12 Motor Temperature Switch	TSH	Vendor	N/A	10-D413	40 74 00	
P25-PSL-0212-1	10-X606	UF Feed Pump 12 Pressure Switch Low	PSL	Contractor	I004	10-D404	40 73 00	Refer to 40 73 00 Schedule
P25-AIT-0221-2	10-X612	CIP Skid 1 pH Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D402	46 61 33	
P25-LIT-0221-1	10-X612	CIP Tank 1 Level Indicating Transmitter	LIT	Vendor	By Vendor	10-D402	46 61 33	
P25-FIT-0221-3	10-X612	CIP Pump 1 Discharge Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D402	46 61 33	
P25-PIT-0221-4	10-X612	CIP Pump 1 Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D402	46 61 33	
P25-TIT-0221-1	10-X612	CIP Tank 1 Temperature Indicating Transmitter	TIT	Vendor	By Vendor	10-D402	46 61 33	
P25-PIT-0226-1	10-X612	CIP Skid 1 Air Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D402	46 61 33	
P25-PIT-0221-2	10-X612	CIP Pump 1 Discharge Header Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D402	46 61 33	
P25-AE-0221-2	10-X612	CIP Skid 1 pH Analysis Element	AE	Vendor	By Vendor	10-D402	46 61 33	

P25-FE-0221-3	10-X612	CIP Pump 1 Discharge Flow Element	FE	Vendor	By Vendor	10-D402	46 61 33	
P25-PIT-0222-2	10-X613	CIP Pump 2 Discharge Header Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D402	46 61 33	
P25-PIT-0230-1	10-X613	CIP Skid 2 Air Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D402	46 61 33	
P25-AIT-0222-2	10-X613	CIP Skid 2 pH Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D402	46 61 33	
P25-TIT-0222-1	10-X613	CIP Tank 2 Temperature Indicating Transmitter	TIT	Vendor	By Vendor	10-D402	46 61 33	
P25-PIT-0222-4	10-X613	CIP Pump 2 Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D402	46 61 33	
P25-AE-0222-2	10-X613	CIP Skid 2 pH Analysis Element	AE	Vendor	By Vendor	10-D402	46 61 33	
P25-LIT-0222-1	10-X613	CIP Tank 2 Level Indicating Transmitter	LIT	Vendor	By Vendor	10-D402	46 61 33	
P25-FIT-0222-3	10-X613	CIP Pump 2 Discharge Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D402	46 61 33	
P25-FE-0222-3	10-X613	CIP Pump 2 Discharge Flow Element	FE	Vendor	By Vendor	10-D402	46 61 33	
P25-LE-0250-1	10-X614	Backwash Tank Cell 1 Level Element	LE	Contractor	I001	10-D410	40 72 00	Refer to 40 72 00 Schedule
P25-LE-0250-3	10-X614	Backwash Tank Cell 3 Level Element	LE	Contractor	I001	10-D410	40 72 00	Refer to 40 72 00 Schedule
P25-LE-0250-2	10-X614	Backwash Tank Cell 2 Level Element	LE	Contractor	I001	10-D410	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0250-2	10-X614	Backwash Tank Cell 2 Level Switch High	LSH	Contractor	I002	10-D410	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0250-1	10-X614	Backwash Tank Cell 1 Level Switch High	LSH	Contractor	I002	10-D410	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0250-3	10-X614	Backwash Tank Cell 3 Level Switch High	LSH	Contractor	I002	10-D410	40 72 00	Refer to 40 72 00 Schedule
P25-FIT-0251-1	10-X615	Backwash Recycle Pumps Discharge Flow Indicating Transmitter	FIT	Contractor	I003	10-D406	40 71 00	Refer to 40 71 00 Schedule
P25-TSH-0251-3	10-X615	Backwash Recycle Pump 3 Motor Temperature Switch	TSH	Contractor	N/A	10-D406	40 74 00	
P25-TSH-0252-2	10-X615	Backwash Sludge Pump 2 Motor Temperature Switch	TSH	Contractor	N/A	10-D406	40 74 00	
P25-TSH-0251-2	10-X615	Backwash Recycle Pump 2 Motor Temperature Switch	TSH	Contractor	N/A	10-D406	40 74 00	
P25-TSH-0251-4	10-X615	Backwash Recycle Pump 4 Motor Temperature Switch	TSH	Contractor	N/A	10-D406	40 74 00	
P25-TSH-0252-1	10-X615	Backwash Sludge Pump 1 Motor Temperature Switch	TSH	Contractor	N/A	10-D406	40 74 00	
P25-TSH-0251-1	10-X615	Backwash Recycle Pump 1 Motor Temperature Switch	TSH	Contractor	N/A	10-D406	40 74 00	
P25-FE-0251-1	10-X615	Backwash Recycle Pumps Discharge Flow Element	FE	Contractor	I003	10-D406	40 71 00	Refer to 40 71 00 Schedule
P25-PI-0252-1	10-X615	Backwash Sludge Pump 1 Discharge Pressure Indicator	PI	Contractor	I004	10-D407	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0252-2	10-X615	Backwash Sludge Pump 2 Discharge Pressure Indicator	PI	Contractor	I004	10-D407	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0251-3	10-X615	Backwash Recycle Pump 3 Discharge Pressure Indicator	PI	Contractor	I004	10-D407	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0251-1	10-X615	Backwash Recycle Pump 1 Discharge Pressure Indicator	PI	Contractor	I004	10-D407	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0251-4	10-X615	Backwash Recycle Pump 4 Discharge Pressure Indicator	PI	Contractor	I004	10-D407	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0251-2	10-X615	Backwash Recycle Pump 2 Discharge Pressure Indicator	PI	Contractor	I004	10-D407	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0251-1	10-X615	Backwash Recycle Pump 1 Suction Pressure Switch Low	PSL	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0251-2	10-X615	Backwash Recycle Pump 2 Suction Pressure Switch Low	PSL	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0251-4	10-X615	Backwash Recycle Pump 4 Suction Pressure Switch Low	PSL	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0251-3	10-X615	Backwash Recycle Pump 3 Suction Pressure Switch Low	PSL	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-FIT-0253-2	10-X616	CIP Waste Pumps Discharge Flow Indicating Transmitter	FIT	Contractor	I003	10-D403	40 71 00	Refer to 40 71 00 Schedule
P25-LE-0253-1	10-X616	Chemical Waste Tank Level Element	LE	Contractor	I001	10-D416	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0253-1	10-X616	Chemical Waste Tank Level Switch High	LSH	Contractor	I002	10-D416	40 72 00	
P25-FIT-0253-3	10-X616	Backwash Sludge Pumps Discharge Flow Indicating Transmitter	FIT	Contractor	I003	10-D403	40 71 00	Refer to 40 71 00 Schedule
P25-AIT-0254-1	10-X616	CIP Waste & Backwash Sludge pH Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D403	40 75 00	
P25-AIT-0254-2	10-X616	CIP Waste & Backwash Sludge ORP Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D403	40 75 00	
P25-FE-0253-2	10-X616	CIP Waste Pumps Discharge Flow Element	FE	Contractor	I003	10-D403	40 71 00	Refer to 40 71 00 Schedule
P25-FE-0253-3	10-X616	Backwash Sludge Pumps Discharge Flow Element	FE	Contractor	I003	10-D403	40 71 00	Refer to 40 71 00 Schedule
P25-PI-0253-1	10-X616	CIP Waste Pump 1 Discharge Pressure Indicator	PI	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0253-2	10-X616	CIP Waste Pump 2 Discharge Pressure Indicator	PI	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0253-2	10-X616	CIP Waste Pump 2 Suction Pressure Switch Low	PSL	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0253-1	10-X616	CIP Waste Pump 1 Suction Pressure Switch low	PSL	Contractor	I004	10-D406	40 73 00	Refer to 40 73 00 Schedule
P25-LSL-0255-1	10-X616	Sump Level Switch Low	LSL	Vendor	By Vendor	10-P104	22 00 00	
P25-LSH-0255-1A	10-X616	Sump Level Switch High	LSH	Vendor	By Vendor	10-P104	22 00 00	
P25-LSH-0255-1B	10-X616	Sump Level Switch High	LSH	Vendor	By Vendor	10-P104	22 00 00	

P25-LSHH-0255-1	10-X616	Sump Level Switch High High	LSHH	Vendor	By Vendor	10-P104	22 00 00	
P25-PI-0231-7	10-X617	Secondary Air Receiver 1 Pressure Indicator	PI	Vendor	By Vendor	10-D405	46 61 33	
P25-PSL-0231-7	10-X617	Secondary Air Receiver 1 Pressure Switch Low	PSL	Vendor	By Vendor	10-D405	46 61 33	
P25-PSH-0231-7	10-X617	Secondary Air Receiver 1 Pressure Switch High	PSH	Vendor	By Vendor	10-D405	46 61 33	
P25-PI-0232-7	10-X617	Secondary Air Receiver 2 Pressure Indicator	PI	Vendor	By Vendor	10-D405	46 61 33	
P25-PSL-0232-7	10-X617	Secondary Air Receiver 2 Pressure Switch Low	PSL	Vendor	By Vendor	10-D405	46 61 33	
P25-PSH-0232-7	10-X617	Secondary Air Receiver 2 Pressure Switch High	PSH	Vendor	By Vendor	10-D405	46 61 33	
P25-PIT-0234-1	10-X617	Air Header Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D405	46 61 33	
P25-WE-0301-1	10-X618	Chlorine Gas Scale 1 Weight Element	WE	Vendor	By Vendor	10-D416	46 31 11.01	
P25-WE-0301-2	10-X618	Chlorine Gas Scale 2 Weight Element	WE	Vendor	By Vendor	10-D416	46 31 11.01	
P25-WE-0301-3	10-X618	Chlorine Gas Scale 3 Weight Element	WE	Vendor	By Vendor	10-D416	46 31 11.01	
P25-WIT-0301-1	10-X618	Chlorine Gas Scale 1 Weight Indicating Transmitter	WIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-WIT-0301-2	10-X618	Chlorine Gas Scale 2 Weight Indicating Transmitter	WIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-WIT-0301-3	10-X618	Chlorine Gas Scale 3 Weight Indicating Transmitter	WIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AE-0300-1	10-X618	Chlorine Room Chlorine Analysis Element 1	AE	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AE-0300-2	10-X618	Chlorine Room Chlorine Analysis Element 2	AE	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AIT-0300-1	10-X618	Chlorine Room Chlorine Analysis Indicating Transmitter 1	AIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AIT-0300-2	10-X618	Chlorine Room Chlorine Analysis Indicating Transmitter 2	AIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-PSH-0301-3	10-X618	Chlorine Gas Header Pressure Switch High	PSH	Vendor	By Vendor	10-D416	46 31 11.01	
P25-HS-0301-4	10-X618	Chlorinator 1 Hand Switch	HS	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZIT-0301-4	10-X618	Chlorinator 1 Position Indicating Transmitter	ZIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZC-0301-4	10-X618	Chlorinator 1 Position Controller	ZC	Vendor	By Vendor	10-D416	46 31 11.01	
P25-FI-0301-4	10-X618	Chlorinator 1 Flow Indicator	FIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-PSH-0301-4	10-X618	Chlorinator 1 Discharge Pressure Switch High	PSH	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AIT-0301-4	10-X618	Chlorinator 1 Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-HS-0301-5	10-X618	Chlorinator 2 Hand Switch	HS	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZIT-0301-5	10-X618	Chlorinator 2 Position Indicating Transmitter	ZIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZC-0301-5	10-X618	Chlorinator 2 Position Controller	ZC	Vendor	By Vendor	10-D416	46 31 11.01	
P25-FI-0301-5	10-X618	Chlorinator 2 Flow Indicator	FIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-PSH-0301-5	10-X618	Chlorinator 2 Discharge Pressure Switch High	PSH	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AIT-0301-5	10-X618	Chlorinator 2 Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-HS-0301-6	10-X618	Chlorinator 3 Hand Switch	HS	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZIT-0301-6	10-X618	Chlorinator 3 Position Indicating Transmitter	ZIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZC-0301-6	10-X618	Chlorinator 3 Position Controller	ZC	Vendor	By Vendor	10-D416	46 31 11.01	
P25-FI-0301-6	10-X618	Chlorinator 3 Flow Indicator	FIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-PSH-0301-6	10-X618	Chlorinator 3 Discharge Pressure Switch High	PSH	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AIT-0301-6	10-X618	Chlorinator 3 Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-HS-0301-7	10-X618	Chlorinator 4 Hand Switch	HS	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZIT-0301-7	10-X618	Chlorinator 4 Position Indicating Transmitter	ZIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-ZC-0301-7	10-X618	Chlorinator 4 Position Controller	ZC	Vendor	By Vendor	10-D416	46 31 11.01	
P25-FI-0301-7	10-X618	Chlorinator 4 Flow Indicator	FIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-PSH-0301-7	10-X618	Chlorinator 4 Discharge Pressure Switch High	PSH	Vendor	By Vendor	10-D416	46 31 11.01	
P25-AIT-0301-7	10-X618	Chlorinator 4 Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D416	46 31 11.01	
P25-PI-0301-8	10-X619	Chlorinator Booster Pump 1 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-9	10-X619	Chlorinator Booster Pump 2 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-10	10-X619	Chlorinator Booster Pump 3 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-11	10-X619	Chlorinator Booster Pump 4 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-FE-0301-8	10-X619	Chlorinator Booster Pumps 1 & 2 Discharge Flow Element	FE	Vendor	By Vendor	10-D417	40 71 00	Refer to 40 71 00 Schedule
P25-FIT-0301-8	10-X619	Chlorinator Booster Pumps 1 & 2 Discharge Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D417	40 71 00	Refer to 40 71 00 Schedule

P25-FE-0301-10	10-X619	Chlorinator Booster Pumps 3 & 4 Discharge Flow Element	FE	Vendor	By Vendor	10-D417	40 71 00	Refer to 40 71 00 Schedule
P25-FIT-0301-10	10-X619	Chlorinator Booster Pumps 3 & 4 Discharge Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D417	40 71 00	Refer to 40 71 00 Schedule
P25-PI-0301-12A	10-X619	Chlorinator Injector 1 Suction Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-12B	10-X619	Chlorinator Injector 1 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-FI-0301-12	10-X619	Chlorinator Injector 1 Discharge Flow Indicator	FI	Vendor	By Vendor	10-D417	40 71 00	
P25-PI-0301-13A	10-X619	Chlorinator Injector 2 Suction Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-13B	10-X619	Chlorinator Injector 2 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-FI-0301-13	10-X619	Chlorinator Injector 2 Discharge Flow Indicator	FI	Vendor	By Vendor	10-D417	40 71 00	
P25-PI-0301-14A	10-X619	Chlorinator Injector 3 Suction Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-14B	10-X619	Chlorinator Injector 3 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-FI-0301-14	10-X619	Chlorinator Injector 3 Discharge Flow Indicator	FI	Vendor	By Vendor	10-D417	40 71 00	
P25-PI-0301-15A	10-X619	Chlorinator Injector 4 Suction Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0301-15B	10-X619	Chlorinator Injector 4 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D417	40 73 00	Refer to 40 73 00 Schedule
P25-FI-0301-15	10-X619	Chlorinator Injector 4 Discharge Flow Indicator	FI	Vendor	By Vendor	10-D417	40 71 00	
P25-DPI-0301-16	10-X620	Dry Scrubber Differential Pressure Indicator	DPI	Vendor	By Vendor	10-D415	44 40 40	
P25-DPS-0301-16	10-X620	Dry Scrubber Differential Pressure Switch	DPS	Vendor	By Vendor	10-D415	44 40 40	
P25-AE-0301-16	10-X620	Dry Scrubber Discharge Air Chlorine Analysis Element	AE	Vendor	By Vendor	10-D415	44 40 40	
P25-AIT-0301-16	10-X620	Dry Scrubber Discharge Air Chlorine Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D415	44 40 40	
P25-LT-0302-1	10-X621	Coagulant Storage Tank 1 Level Transmitter	LT	Contractor	I006	10-D419	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0302-3	10-X621	Coagulant Storage Area Sump Level Switch High	LSH	Contractor	By Vendor	10-D419	40 72 00	
P25-LSH-0302-1	10-X621	Coagulant Storage Tank 1 Level Switch High	LSH	Contractor	I007	10-D419	40 72 00	
P25-LT-0302-2	10-X621	Coagulant Storage Tank 2 Level Transmitter	LT	Contractor	I006	10-D419	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0302-2	10-X621	Coagulant Storage Tank 2 Level Switch High	LSH	Contractor	I007	10-D419	40 71 00	
P25-PI-0302-2	10-X621	Coagulant Metering Pump 2 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0302-1	10-X621	Coagulant Metering Pump 1 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0302-3	10-X621	Coagulant Metering Pump 3 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-YL-0302-1	10-X621	Coagulant Storage Tank 1 Remote Level Alarm High Indicating Light	YL	Contractor	N/A	10-E422	40 78 00	
P25-YL-0302-2	10-X621	Coagulant Storage Tank 2 Remote Level Alarm High Indicating Light	YL	Contractor	N/A	10-E422	40 78 00	
P25-LI-0302-1C	10-X621	Coagulant Storage Tank 1 Remote Level Indicator	LI	Contractor	N/A	10-E422	40 78 00	
P25-LI-0302-2C	10-X621	Coagulant Storage Tank 2 Remote Level Indicator	LI	Contractor	N/A	10-E422	40 78 00	
P25-LT-0303-1	10-X622	Sodium Bisulfite Storage Tank Level Transmitter	LT	Contractor	I006	10-D419	40 72 00	
P25-LSH-0303-1	10-X622	Sodium Bisulfite Storage Tank Level Switch High	LSH	Contractor	I007	10-D419	40 72 00	
P25-LSH-0303-2	10-X622	Sodium Bilsulfite Storage Area Sump Level Switch High	LSH	Contractor	By Vendor	10-D419	40 72 00	
P25-YL-0303-1	10-X622	Sodium Bisulfite Storage Tank Remote Level Alarm High Indicating Light	YL	Contractor	N/A	10-D419	40 78 00	
P25-LI-0303-1C	10-X622	Sodium Bisulfite Storage Tank Remote Level Indicator	LI	Contractor	N/A	10-D419	40 78 00	
P25-PI-0303-1	10-X622	Sodium Bisulfite Metering Pump 1 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0303-2	10-X622	Sodium Bisulfite Metering Pump 2 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0303-3	10-X622	Sodium Bisulfite Metering Pump 3 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0303-4	10-X622	Sodium Bisulfite Metering Pump 4 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0303-5	10-X622	Sodium Bisulfite Metering Pump 5 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0303-1A	10-X622	Sodium Bisulfite to Clearwell Header 1 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0303-3A	10-X622	Sodium Bisulfite to Clearwell Header 2 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D419	46 33 44	
P25-PI-0304-3	10-X623	Compressed Air Header to Citric Acid Pumps Pressure Indicator	PI	Contractor	I004	10-D420	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0304-1	10-X623	Citric Acid Metering Pump 1 Discharge Pressure Indicator	PI	Contractor	I004	10-D420	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0304-2	10-X623	Citric Acid Metering Pump 2 Discharge Pressure Indicator	PI	Contractor	I004	10-D420	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0310-3	10-X624	Compressed Air Header to Sodium Hypochlorite Pumps Pressure Indicator	PI	Contractor	I004	10-D420	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0310-1	10-X624	Sodium Hypochlorite Metering Pump 1 Discharge Pressure Indicator	PI	Contractor	I004	10-D420	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0310-2	10-X624	Sodium Hypochlorite Metering Pump 2 Discharge Pressure Indicator	PI	Contractor	I004	10-D420	40 73 00	Refer to 40 73 00 Schedule
P25-LIT-0241-6A	10-X625	Backwash Supply Cell 1 Level Indicating Transmitter	LIT	Contractor	I001	10-D403	40 72 00	Refer to 40 72 00 Schedule

P25-LIT-0241-6B	10-X625	Backwash Supply Cell 2 Level Indicating Transmitter	LIT	Contractor	I001	10-D403	40 72 00	Refer to 40 72 00 Schedule
P25-LSH-0240-2	10-X625	Backwash Supply Cell 2 Level Switch High	LSH	Contractor	I002	10-D403	40 72 00	
P25-LSH-0240-1	10-X625	Backwash Supply Cell 1 Level Switch High	LSH	Contractor	I002	10-D403	40 72 00	
P25-TSH-0241-1	10-X625	UF Backwash Pump 1 Motor Temperature Switch	TSH	Vendor	N/A	10-D403	40 74 00	
P25-TSH-0241-2	10-X625	UF Backwash Pump 2 Motor Temperature Switch	TSH	Vendor	N/A	10-D403	40 74 00	
P25-TSH-0241-3	10-X625	UF Backwash Pump 3 Motor Temperature Switch	TSH	Vendor	N/A	10-D403	40 74 00	
P25-PI-0241-2	10-X625	UF Backwash Pump 2 Discharge Pressure Indicator	PI	Contractor	I004	10-D403	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0241-1	10-X625	UF Backwash Pump 1 Discharge Pressure Indicator	PI	Contractor	I004	10-D403	40 73 00	Refer to 40 73 00 Schedule
P25-PI-0241-3	10-X625	UF Backwash Pump 3 Discharge Pressure Indicator	PI	Contractor	I004	10-D403	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0241-1	10-X625	UF Backwash Pump 1 Suction Pressure Switch Low	PSL	Contractor	I004	10-D403	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0241-3	10-X625	UF Backwash Pump 3 Suction Pressure Switch Low	PSL	Contractor	I004	10-D403	40 73 00	Refer to 40 73 00 Schedule
P25-PSL-0241-2	10-X625	UF Backwash Pump 2 Suction Pressure Switch Low	PSL	Contractor	I004	10-D403	40 73 00	Refer to 40 73 00 Schedule
P25-LIT-0305-1	10-X626	LOX Storage Tank Level Indicating Transmitter	LIT	Vendor	By Vendor	10-D415	46 31 53	
P25-PSL-0307-1	10-X626	Nitrogen Storage Tank Pressure Switch Low	PSL	Vendor	By Vendor	10-D418	46 31 53	
P25-DPI-0306-2A	10-X626	GOX Regulating Manifold Filter Differential Pressure Indicator	DPI	Vendor	By Vendor	10-D418	46 31 53	
P25-PIT-0305-1	10-X626	LOX Storage Tank Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D415	46 31 53	
P25-PSH-0307-1	10-X626	Nitrogen Storage Tank Pressure Switch High	PSH	Vendor	By Vendor	10-D418	46 31 53	
P25-DPI-0306-3A	10-X626	GOX Regulating Manifold Discharge Differential Pressure Indicator	DPI	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0307-1	10-X626	Nitrogen Storage Tank Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-DPSH-0307-2C	10-X626	Nitrogen Booster Compressor Skid Filter 3 Differential Pressure Switch High	DPSH	Vendor	By Vendor	10-D418	46 31 53	
P25-DPSH-0307-2A	10-X626	Nitrogen Booster Compressor Skid Filter 1 Differential Pressure Switch High	DPSH	Vendor	By Vendor	10-D418	46 31 53	
P25-DPSH-0307-2B	10-X626	Nitrogen Booster Compressor Skid Filter 2 Differential Pressure Switch High	DPSH	Vendor	By Vendor	10-D418	46 31 53	
P25-FIT-0307-3	10-X626	Nitrogen Booster Compressor Skid Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D418	46 31 53	
P25-FE-0307-3	10-X626	Nitrogen Booster Compressor Skid Thermal Mass Flow Element	FE	Vendor	By Vendor	10-D418	46 31 53	
P25-PIT-0306-3A	10-X626	GOX Regulating Manifold Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D418	46 31 53	
P25-TIT-0306-3A	10-X626	GOX Regulating Manifold Discharge Temperature Indicating Transmitter	TIT	Vendor	By Vendor	10-D418	46 31 53	
P25-TIT-0305-1A	10-X626	LOX Vaporizer 1 Discharge Pressure Indicating Transmitter	TIT	Vendor	By Vendor	10-D415	46 31 53	
P25-PIT-0305-2A	10-X626	LOX Vaporizer 2 Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D415	46 31 53	
P25-TIT-0305-2A	10-X626	LOX Vaporizer 2 Discharge Temperature Indicating Transmitter	TIT	Vendor	By Vendor	10-D415	46 31 53	
P25-PIT-0305-1A	10-X626	LOX Vaporizer 1 Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D415	46 31 53	
P25-PIT-0306-1B	10-X626	GOX Regulating Manifold Filter Suction Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0309-3B	10-X627	Ozone Chillers Cooling Water Return PRV Suction Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0309-3A	10-X627	Ozone Chillers Cooling Water Return PRV Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-YL-0308-5D	10-X627	Ozone System Alarm Light	YL	Vendor	By Vendor	N/A	46 31 53	Mounted to MCP-0305-1
P25-AIT-0308-5A	10-X627	Ozone Room Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D418	46 31 53	
P25-AE-0308-5A	10-X627	Ozone Room Ozone Analysis Element	AE	Vendor	By Vendor	10-D418	46 31 53	
P25-AIT-0308-5B	10-X627	Ozone Room Oxygen Analysis Indicating Transmitter	AIT	Vendor	By Vendor	10-D418	46 31 53	
P25-AE-0308-5B	10-X627	Ozone Room Oxygen Analysis Element	AE	Vendor	By Vendor	10-D418	46 31 53	
P25-YA-0308-5C	10-X627	Ozone System Alarm Horn	YA	Vendor	By Vendor	10-D418	46 31 53	
P25-FIT-0308-6A	10-X628	Ozone Injection Skid Motive Water Inlet Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D418	46 31 53	
P25-LSH-0308-5	10-X628	Ozone Injection Pump Skid Ozone Tank Level Switch High	LSH	Vendor	By Vendor	10-D418	46 31 53	
P25-FIT-0308-5	10-X628	Ozone Injection Skid Ozone Inlet Flow Indicating Transmitter	FIT	Vendor	By Vendor	10-D418	46 31 53	
P25-AE-0402-1B	10-X628	Sample Pump 4 Discharge Analysis Element	AE	Contractor	By Vendor	10-D408	40 75 00	
P25-AIT-0402-1A	10-X628	Sample Pump 3 Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D408	40 75 00	
P25-AIT-0402-1B	10-X628	Sample Pump 4 Discharge Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D408	40 75 00	
P25-AE-0401-1A	10-X628	Sample Pump 1 Discharge Analysis Element	AE	Contractor	By Vendor	10-D408	40 75 00	
P25-AIT-0401-1B	10-X628	Sample Pump 2 Discharge Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D408	40 75 00	
P25-AE-0402-1A	10-X628	Sample Pump 3 Discharge Analysis Element	AE	Contractor	By Vendor	10-D408	40 75 00	
P25-AIT-0401-1A	10-X628	Sample Pump 1 Discharge Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D408	40 75 00	

P25-AE-0401-1B	10-X628	Sample Pump 2 Discharge Analysis Element	AE	Contractor	By Vendor	10-D408	40 75 00	
P25-FE-0308-6A	10-X628	Ozone Injection Pump Skid Motive Water Inlet Flow Element	FE	Vendor	By Vendor	10-D418	46 31 53	
P25-FE-0308-5	10-X628	Ozone Injection Skid Ozone Inlet Flow Element	FE	Vendor	By Vendor	10-D418	46 31 53	
P25-FI-0401-1A	10-X628	Sample Pump 1 Discharge Flow Indicator	FI	Contractor	By Vendor	10-D408	40 71 00	
P25-FI-0402-1B	10-X628	Sample Pump 4 Discharge Flow Indicator	FI	Contractor	By Vendor	10-D408	40 71 00	
P25-FI-0402-1A	10-X628	Sample Pump 3 Discharge Flow Indicator	FI	Contractor	By Vendor	10-D408	40 71 00	
P25-FI-0401-1B	10-X628	Sample Pump 2 Discharge Flow Indicator	FI	Contractor	By Vendor	10-D408	40 71 00	
P25-PIT-0308-7B	10-X628	Ozone Injection Pump 2 Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0308-7B	10-X628	Ozone Injection Pump 2 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-PSH-0308-7B	10-X628	Ozone Injection Pump 2 Discharge Pressure Switch High	PSH	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0308-7A	10-X628	Ozone Injection Pump 2 Suction Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0308-6B	10-X628	Ozone Injection Pump 1 Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-PSH-0308-6B	10-X628	Ozone Injection Pump 1 Discharge Pressure Switch High	PSH	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0308-6A	10-X628	Ozone Injection Pump 1 Suction Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-PIT-0308-6B	10-X628	Ozone Injection Pump 1 Discharge Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D418	46 31 53	
P25-PIT-0308-6A	10-X628	Ozone Injection Skid Motive Water Inlet Pressure Indicating Transmitter	PIT	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0308-5B	10-X628	Ozone Injection Pump Skid Ozonated Water Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-PI-0308-5A	10-X628	Ozone Injection Pump Skid Ozone Tank Discharge Pressure Indicator	PI	Vendor	By Vendor	10-D418	46 31 53	
P25-AIT-0204-13B	10-X628	UF Filtrate Total Suspended Solids Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D408	40 75 00	
P25-AIT-0204-13A	10-X628	UF Filtrate Turbidity Analysis Indicating Transmitter	AIT	Contractor	By Vendor	10-D408	40 75 00	
P25-ZSO-0401-3	20-X601	East Clearwell Hatch Intrusion Switch 3	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-LIT-0402-1	20-X601	West Clearwell Ozone Contact Basin Level Indicating Transmitter	LIT	Contractor	I001	20-D101	40 72 00	
P25-ZSO-0403-1	20-X601	Clearwells Drain Vault Hatch Intrusion Switch 1	ZSO	Contractor	N/A	20-E108	26 05 90	
P25-AE-0403-1	20-X601	Clearwells Drain Vault Sample Analysis Element	AE	Contractor	N/A	20-D103	40 75 00	
P25-ZSO-0401-2	20-X601	East Clearwell Hatch Intrusion Switch 2	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-PG-0403-1B	20-X601	East Clearwell Drain Line Pressure Gauge	PG	Contractor	I012	20-D103	40 73 00	
P25-LSH-0401-1	20-X601	Clearwells Emergency Overflow Trough Level Switch High	LSH	Contractor	N/A	20-E106	26 05 90	
P25-LSHH-0403-1	20-X601	Clearwells Drain Vault Level Switch High High	LSHH	Contractor	N/A	20-D103	40 72 00	
P25-ZSO-0402-3	20-X601	West Clearwell Hatch Intrusion Switch 3	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-AIT-0403-1	20-X601	Clearwells Drain Vault Sample Analysis Indicating Transmitter	AIT	Contractor	N/A	20-D103	40 75 00	
P25-LSH-0403-2	20-X601	Clearwells Drain Vault Sump Pump Level Switch High	LSH	Vendor	N/A	20-D103	22 14 29	Supplied with Sump Pump PMP-0403-2
P25-ZSO-0401-1	20-X601	East Clearwell Hatch Intrusion Switch 1	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-ZSO-0402-2	20-X601	West Clearwell Hatch Intrusion Switch 2	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-PG-0403-1A	20-X601	West Clearwell Drain Line Pressure Gauge	PG	Contractor	I012	20-D103	40 73 00	
P25-ZSO-0402-4	20-X601	West Clearwell Hatch Intrusion Switch 4	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-ZSO-0402-1	20-X601	West Clearwell Hatch Intrusion Switch 1	ZSO	Contractor	N/A	20-E106	26 05 90	
P25-LIT-0401-1	20-X601	East Clearwell Ozone Contact Basin Level Indicating Transmitter	LIT	Contractor	I001	20-D101	40 72 00	
P25-ZSO-0403-2	20-X601	Clearwells Drain Vault Hatch Intrusion Switch 2	ZSO	Contractor	N/A	20-E108	26 05 90	
P25-PIT-0403-1A	20-X601	West Clearwell Drain Line Pressure Indicating Transmitter	PIT	Contractor	I012	20-D103	40 73 00	
P25-PIT-0403-1B	20-X601	East Clearwell Drain Line Pressure Indicating Transmitter	PIT	Contractor	I012	20-D103	40 73 00	
P25-LSHH-0410-1	20-X602	High Service Pump Station Sump Level Switch High High	LSHH	Contractor	N/A	20-D104	40 72 00	
P25-TE-0411-1#	20-X602	High Service Pump 1 Motor RTDs	LE	Vendor	N/A	20-D105	40 74 00	8 RTD Per High Service Pump Motor
P25-VE-0411-1	20-X602	High Service Pump 1 Vibration Element	VE	Vendor	N/A	20-D105	43 21 13	
P25-ZSC-0411-1	20-X602	High Service Pump 1 Discharge Valve Limit Switch Closed	ZSC	Vendor	N/A	20-D105	40 23 13.07	
P25-ZSO-0411-1	20-X602	High Service Pump 1 Discharge Valve Limit Switch Open	ZSO	Vendor	N/A	20-D105	40 23 13.07	
P25-PSH-0411-1	20-X602	High Service Pump 1 Discharge Pressure Switch High	PSH	Contractor	I004	20-D105	40 73 00	
P25-TE-0412-1#	20-X602	High Service Pump 2 Motor RTDs	LE	Vendor	N/A	20-D105	40 74 00	8 RTD Per High Service Pump Motor
P25-VE-0412-1	20-X602	High Service Pump 2 Vibration Element	VE	Vendor	N/A	20-D105	43 21 13	
P25-ZSC-0412-1	20-X602	High Service Pump 2 Discharge Valve Limit Switch Closed	ZSC	Vendor	N/A	20-D105	40 23 13.07	

P25-ZSO-0412-1	20-X602	High Service Pump 2 Discharge Valve Limit Switch Open	ZSO	Vendor	N/A	20-D105	40 23 13.07	
P25-PSH-0412-1	20-X602	High Service Pump 2 Discharge Pressure Switch High	PSH	Contractor	I004	20-D105	40 73 00	
P25-TE-0413-1#	20-X602	High Service Pump 3 Motor RTDs	LE	Vendor	N/A	20-D105	40 74 00	8 RTD Per High Service Pump Motor
P25-VE-0413-1	20-X602	High Service Pump 3 Vibration Element	VE	Vendor	N/A	20-D105	43 21 13	
P25-ZSC-0413-1	20-X602	High Service Pump 3 Discharge Valve Limit Switch Closed	ZSC	Vendor	N/A	20-D105	40 23 13.07	
P25-ZSO-0413-1	20-X602	High Service Pump 3 Discharge Valve Limit Switch Open	ZSO	Vendor	N/A	20-D105	40 23 13.07	
P25-PSH-0413-1	20-X602	High Service Pump 3 Discharge Pressure Switch High	PSH	Contractor	I004	20-D105	40 73 00	
P25-TE-0414-1#	20-X602	High Service Pump 4 Motor RTDs	LE	Vendor	N/A	20-D105	40 74 00	8 RTD Per High Service Pump Motor
P25-VE-0414-1	20-X602	High Service Pump 4 Vibration Element	VE	Vendor	N/A	20-D105	43 21 13	
P25-ZSC-0414-1	20-X602	High Service Pump 4 Discharge Valve Limit Switch Closed	ZSC	Vendor	N/A	20-D105	40 23 13.07	
P25-ZSO-0414-1	20-X602	High Service Pump 4 Discharge Valve Limit Switch Open	ZSO	Vendor	N/A	20-D105	40 23 13.07	
P25-PSH-0414-1	20-X602	High Service Pump 4 Discharge Pressure Switch High	PSH	Contractor	I004	20-D105	40 73 00	
P25-TE-0415-1#	20-X602	High Service Pump 5 Motor RTDs	LE	Vendor	N/A	20-D105	40 74 00	8 RTD Per High Service Pump Motor
P25-VE-0415-1	20-X602	High Service Pump 5 Vibration Element	VE	Vendor	N/A	20-D105	43 21 13	
P25-ZSC-0415-1	20-X602	High Service Pump 5 Discharge Valve Limit Switch Closed	ZSC	Vendor	N/A	20-D105	40 23 13.07	
P25-ZSO-0415-1	20-X602	High Service Pump 5 Discharge Valve Limit Switch Open	ZSO	Vendor	N/A	20-D105	40 23 13.07	
P25-PSH-0415-1	20-X602	High Service Pump 5 Discharge Pressure Switch High	PSH	Contractor	I004	20-D105	40 73 00	
P25-PSL-0416-1	20-X602	High Service Pump Station Suction Header Pressure Switch Low	PSL	Contractor	I004	20-D104	40 73 00	
P25-PIT-0417-1	20-X602	High Service Pump Station Discharge Header Pressure Indicating Transmitter	PIT	Contractor	I008	20-D105	40 73 00	
P25-PI-0417-1	20-X602	High Service Pump Station Discharge Header Pressure Indicator	PIT	Contractor	I008	20-D105	40 73 00	
P25-FE-0417-1	20-X602	High Service Pump Station Discharge Header Flow Element	FE	Contractor	I003	20-D105	40 71 00	
P25-FIT-0417-1	20-X602	High Service Pump Station Discharge Header Flow Indicating Transmitter	FIT	Contractor	I003	20-D105	40 71 00	
P25-FSL-0417-1	20-X602	High Service Pump Station Discharge Header Flow Switch Low	FSL	Contractor	I003	20-D105	40 71 00	Integral to Flow Indicating Transmitter
P25-LSH-0407-1	20-X602	High Service Pump Station Sump Pump Level Switch High	LSH	Contractor	N/A	20-D104	22 14 29	
P25-TIT-0418-1A	20-X602	High Service Pump Station Discharge Sample Temperature Indicating Transmitter	TIT	Contractor	1/20-D505	20-D105	40 74 00	
P25-AIT-0418-1B	20-X602	High Service Pump Station Discharge Sample Analysis Indicating Transmitter	AIT	Contractor	1/20-D505	20-D105	40 75 00	
P25-DPIT-0417-1	20-X602	Surge Bladder 1 Differential Pressure Indicating Transmitter	DPIT	Contractor	By Vendor	20-D105	43 41 16	
P25-DPIT-0417-1	20-X602	Surge Bladder 2 Differential Pressure Indicating Transmitter	DPIT	Contractor	By Vendor	20-D105	43 41 16	
P25-PIT-0401-1	20-X603	Ozone Demister 1 Suction Pressure Indicating Transmitter	PIT	Vendor	By Vendor	20-D105	46 31 53	
P25-DPS-0401-1	20-X603	Ozone Demister 1 Differential Pressure Switch	DPS	Vendor	By Vendor	20-D105	46 31 53	
P25-PIT-0401-3	20-X603	Ozone Destruction Unit 1 Blower Suction Pressure Indicating Transmitter	PIT	Vendor	By Vendor	20-D105	46 31 53	
P25-TIT-0401-3	20-X603	Ozone Destruction Unit 1 Blower Suction Temperature Indicating Transmitter	TIT	Vendor	By Vendor	20-D105	46 31 53	
P25-TIT-0401-4	20-X603	Ozone Destruction Unit 1 Inlet Temperature Indicating Transmitter	TIT	Vendor	By Vendor	20-D105	46 31 53	
P25-AE-0403-2	20-X603	Ozone Destruction Unit 1 Discharge Ozone Analysis Element	AE	Vendor	By Vendor	20-D105	46 31 53	
P25-AIT-0403-2	20-X603	Ozone Destruction Unit 1 Discharge Ozone Analysis Indicating Transmitter	AIT	Vendor	By Vendor	20-D105	46 31 53	
P25-PIT-0402-1	20-X603	Ozone Demister 2 Suction Pressure Indicating Transmitter	PIT	Vendor	By Vendor	20-D105	46 31 53	
P25-DPS-0402-1	20-X603	Ozone Demister 2 Differential Pressure Switch	DPS	Vendor	By Vendor	20-D105	46 31 53	
P25-PIT-0402-3	20-X603	Ozone Destruction Unit 2 Blower Suction Pressure Indicating Transmitter	PIT	Vendor	By Vendor	20-D105	46 31 53	
P25-TIT-0402-3	20-X603	Ozone Destruction Unit 2 Blower Suction Temperature Indicating Transmitter	TIT	Vendor	By Vendor	20-D105	46 31 53	
P25-TIT-0402-4	20-X603	Ozone Destruction Unit 2 Inlet Temperature Indicating Transmitter	TIT	Vendor	By Vendor	20-D105	46 31 53	
P25-AE-0404-2	20-X603	Ozone Destruction Unit 2 Discharge Ozone Analysis Element	AE	Vendor	By Vendor	20-D105	46 31 53	
P25-AIT-0404-2	20-X603	Ozone Destruction Unit 2 Discharge Ozone Analysis Indicating Transmitter	AIT	Vendor	By Vendor	20-D105	46 31 53	
P25-LSHH-0419-1	30-X601	Transmission Pipeline Vault Level Switch High High	LSHH	Contractor	By Vendor	30-D101	40 72 00	
P25-ZSO-0419-1	30-X601	Transmission Pipeline Vault Hatch Intrusion Switch 1	ZSO	Contractor	By Vendor	30-D101	26 05 90	
P25-ZSO-0419-2	30-X601	Transmission Pipeline Vault Hatch Intrusion Switch 2	ZSO	Contractor	By Vendor	30-D101	26 05 90	

SECTION 40 71 00
FLOW MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide flow measurement instrumentation as specified in this section and in compliance with section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and Testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.

- B. Submit shop drawings for each specified instrument together with a completed Instrument Data Sheet in accordance with ISA S20 standard.

- 1. Each instrumentation submittal shall include a copy of the respective specification section marked up to show compliance or non-compliance with specified requirements. Provide written justification for any non-compliance features.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sustainability Standards Certifications.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

1.07 WARRANTY

- A. As specified in Division 1.

PART 2 - PRODUCTS

2.01 MAGNETIC IN-LINE FLOW METERS

- A. Magnetic in-line flow meters provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
 - 1. Each magnetic flow meter and signal converter/transmitter shall be tagged in accordance with the Instrumentation List and as shown on the P&ID drawings.
 - 2. Flow tubes shall be flanged and lined full-lay-length flow tube suitably rated for the respective process piping pressure rating.
 - 3. Flow tube sizes shall generally be as shown on the contract drawings. Notify the Engineer if the proposed flow meter size will result in flow velocity lower than 1 ft/sec or greater than 16 ft/sec during normal operation.
 - 4. Liner material shall be selected for compatibility with the process application chemical characteristics and operating temperature range.
 - 5. Measuring electrodes and built-in grounding electrodes shall be 316SS bullet-nose unless an alternate material is required for application specific chemical resistance.

6. Line size 316SS grounding/protection rings shall be provided for applications with abrasive slurries and where the process piping system is non-conductive or has a non-conductive liner.
 7. Signal converters/transmitters shall be suitable 120 VAC power supply or as otherwise specified and shall have an accuracy of 0.5 percent of calibrated span or better. Outputs shall include 4-20maDC analog and a Totalizer Pulse output as a minimum.
 8. Provide remote wall mounted signal converters with pre-terminated power and signal cables to facilitate installation of the signal converter at 5.5 ft above finished floor. The signal converter may be mounted directly to the flow tube where the installed height of the signal converter display is between 4 ft – 6 ft above finished floor.
- B. The flow tube, signal converter, and related ancillaries shall have environmental ratings suitable for their respective process areas. In no case shall the flow tube or signal converter environmental rating be less than NEMA 4X.
- C. Suitable manufacturers of magnetic flow meters include;
1. Siemens
 2. Endress + Hauser
 3. Rosemount

2.02 FLOW INDICATING ROTAMETER

- A. Flow indicating rotameters provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
- B. Each rotameter shall be tagged in accordance with the Instrumentation List and as shown on the P&ID drawings.
- C. Requirements
1. Polysulfone body
 2. Full scale accuracy +/- 4%
 3. Flow range: 0.1 – 10 GPM
 4. Operates under pressures up to 175 PSI
 5. Maximum fluid temperature 212°F
 6. Float and Guide Rod: 316SS

D. Suitable manufacturers include:

1. Blue-White, F-450
2. Approved Equal

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. Flow meters are to be set up, configured, and calibrated by Journeyman instrumentation technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION

- A. Install primary flow elements and signal converters in accordance with manufacturer's installation instructions.
1. For magnetic flow meters, flow tubes shall be installed in a designated "meter run" comprising a minimum upstream straight pipe length of 5D and downstream straight pipe length of 3D of the nominal pipe diameter. There shall be no valves, bends, tees, process taps, chemical injectors or other flow disturbing fittings located within the Meter Run. The Meter Run piping shall be the same size as the meter.

3.03 CALIBRATION

- A. Flow meters shall be factory pre-calibrated and calibration shall be verified on site.
- B. Provide printed calibration reports of the factory calibration and as-commissioned in-situ calibration check including all smart device configuration parameters.
1. In line liquid flow meter calibrations shall be verified in-situ using volumetric draw down or similar test approved by the Engineer.
- C. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

3.05 SCHEDULES

SCHEDULE 1 TO SECTION 40 71 00 ELECTROMAGNETIC FLOW METER SCHEDULE

Tag No.	DWG No.	Description	Service	Min Flow (GPM)	Calibrated Range GPM	Size (in.)	Materials of Construction																									
P25-FE/FIT-0102-2	01-X601	Raw Water Irrigation Pump Discharge Flow	RW	100	0 - 100	1	2,5,11,12,14																									
P25-FE/FIT-0302-1	10-X601	Raw Water to In-Line Flash Reactor Flow	RW	1000	1000-2090	12	2,5,11,12,14																									
P25-FE/FIT-0303-1	10-X601	Raw Water Plant Influent Flow	RW	0	0 - 21000	42	2,5,11,12,14																									
P25-FE/FIT-0221-3	10-X612	CIP Pump 1 Discharge Flow	CSF	By Vendor	By Vendor	6	By Vendor																									
P25-FE/FIT-0222-3	10-X613	CIP Pump 2 Discharge Flow	CSF	By Vendor	By Vendor	6	By Vendor																									
P25-FE/FIT-0251-1	10-X615	Backwash Recycle Pumps Discharge Flow	BWR	0	0 - 2100	10	2,5,11,12,14																									
P25-FE/FIT-0253-2	10-X616	CIP Waste Pumps Discharge Flow	DR	0	0 – 60	2	2,5,11,12,14																									
P25-FE/FIT-0253-3	10-X616	Backwash Sludge Pumps Discharge Flow	SLG	0	0 – 300	4	2,5,11,12,14																									
P25-FE/FIT-0302-10	10-X619	Chlorinator Booster Pumps 1 & 2 Discharge Flow	UFF	0	0 - 30	2	2,5,11,12,14																									
P25-FE/FIT-0301-8	10-X619	Chlorinator Booster Pumps 3 & 4 Discharge Flow	UFF	0	0 – 15	1	2,5,11,12,14																									
P25-FE/FIT-0308-5	10-X628	Ozone Injection Pump Skid Ozone Inlet Flow	OZG	By Vendor	By Vendor	2	By Vendor																									
P25-FE/FIT-0308-6A	10-X628	Ozone Injection Pump Skid Motive Water Inlet Flow	MW	By Vendor	By Vendor	3	By Vendor																									
P25-FE/FIT-0417-1	20-X601	High Service Pump Station Discharge Header Flow	FW	0	0 - 21000	28	2,5,11,12,15																									
<table><tr><td><u>Electrode Type</u></td><td><u>Liner Material</u></td><td><u>Electrode Material</u></td><td><u>Flange Material</u></td><td><u>Flange Rating</u></td></tr><tr><td>1. Plain (Flush)</td><td>4. Teflon</td><td>8. Zirconium</td><td>12. Carbon Steel</td><td>14. ANSI 150</td></tr><tr><td>2. Bullet Nose</td><td>5. Polyurethane</td><td>9. Tantalum</td><td>13. 304 Stainless Steel</td><td>15. ANSI 300</td></tr><tr><td>3. Remov. Under Press.</td><td>6. Neoprene</td><td>10. Hastelloy. “C”</td><td></td><td></td></tr><tr><td></td><td>7. Hard Rubber</td><td>11. 316 Stainless Steel</td><td></td><td></td></tr></table>								<u>Electrode Type</u>	<u>Liner Material</u>	<u>Electrode Material</u>	<u>Flange Material</u>	<u>Flange Rating</u>	1. Plain (Flush)	4. Teflon	8. Zirconium	12. Carbon Steel	14. ANSI 150	2. Bullet Nose	5. Polyurethane	9. Tantalum	13. 304 Stainless Steel	15. ANSI 300	3. Remov. Under Press.	6. Neoprene	10. Hastelloy. “C”				7. Hard Rubber	11. 316 Stainless Steel		
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END OF SECTION

SECTION 40 72 00
LEVEL MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide level measurement instrumentation as specified in this section and in compliance with Section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.

- B. Submit shop drawings for each specified instrument together with a completed Instrument Data Sheet in accordance with ISA S20 standard.

- 1. Each instrumentation submittal shall include a copy of the respective specification section marked up to show compliance or non-compliance with specified requirements. Provide written justification for any non-compliance features.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

1.07 WARRANTY

- A. Comply with the requirements specified in Section 01 78 36.

PART 2 - PRODUCTS

2.01 RADAR LEVEL TRANSMITTERS

- A. Radar level meters provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.

- 1. Each radar level transmitter and corresponding antenna shall be tagged in accordance with the Instrumentation List and as shown on the P&ID drawings.
 - 2. Level transmitters shall be pulsed radar type and shall have an accuracy of plus or minus 0.1 percent of calibrated span or better.
 - 3. Level transmitters shall accept 120 VAC nominal power supply from an external dedicated circuit.
 - 4. The transmitter shall be a smart programmable type with local display and programming keypad.
 - 5. Outputs shall include 4-20maDC analog and three programmable relay outputs as a minimum.
 - 6. The antenna model shall be selected for optimum performance at the required measurement range and process vessel configuration for each application. The antenna shall include a quick-disconnect feature to facilitate maintenance.

7. Provide antenna with pre-terminated signal cable of adequate length to facilitate installation of the transmitter at 5.5 feet above finished floor and with enough slack to facilitate sensor removal and inspection without requiring cable disconnection. Supply a minimum cable length of 15 feet.
 8. Design the antenna mounting bracket(s) and/or stilling well to ensure that the sensor is mounted at least 300 mm above the maximum possible liquid level. Where potential sensor flooding is anticipated, provide the sensor with a flood proof hood.
 9. Provide a 316SS stilling well for the transducer in accordance with the manufacturers recommendations where the process vessel has turbulent liquid surface conditions, floating foam, floating debris, or when there are stationary objects in the transducer beam path. Stilling wells shall have flanged transducer mounting to facilitate transducer maintenance activities.
 10. Orient the antenna rotationally such that non liquid and indirect reflections are minimized.
- B. The transmitter, antenna, cabling and related ancillaries shall have environmental ratings suitable for their respective process areas. In no case shall the transmitter, transducer, or cabling environmental rating be less than NEMA 4X.
- C. Suitable manufacturers of radar level meters include:
1. Siemens, LR100/LR110/LR120
 2. Endress + Hauser, Micropilot M
 3. Ametek Drexelbrook, DR7000
- 2.02 ULTRASONIC AND CAPACITANCE TYPE SWITCHES AND TRANSMITTERS:
- A. Device output shall be impervious to material build-up on sensor.
 - B. Sensor coatings, if any, shall be as specified on the instrument data sheets. Sensor coatings shall be compatible with the process fluids.
 - C. Rigid sensors shall be heavy duty.
 - D. Flexible sensors shall be held vertically straight using a weight attached to the end of the sensor, or a turnbuckle tensioning system attached between the sensor and the tank or bin bottom.
 - E. Enclosures shall meet the appropriate NEMA rating as specified on the instrument data sheets.
 - F. Continuous level measurement systems shall have 2-wire 4-20 mA outputs.

G. On-off level measurement systems shall have DPDT action, with voltage and current ratings as specified on the instrument data sheets. Switches shall have sealed isolated dry contacts. For vendor supplied equipment packages, switches shall be rated for the requirements of the equipment.

H. Suitable manufacturers of Ultrasonic and Capacitance Type Switches and Transmitters:

1. Siemens
2. Endress + Hauser
3. Ametek Drexelbrook

2.03 LEVEL SWITCHES

A. Float level switches provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.

1. Float switches shall have SPDT output contacts rated for pilot duty. Switches shall be mercury-free.
2. Provide polypropylene float casing with pre-terminated signal cable. Float switch density shall be selected for optimal performance in the specified process liquid.
3. Extension cable shall be 3 conductor 50 foot length minimum with cable length determined in the field based on application and depth of vessel.

B. The level switch, cabling and related ancillaries shall have environmental ratings suitable for their respective process areas. In no case shall the transmitter, or cabling environmental rating be less than NEMA 4X.

C. Suitable manufacturers of level switches include:

1. Flygt ENM-10.
2. ITT Centripro A2N Series.
3. Approved equal

PART 3 - EXECUTION

3.01 QUALIFICATIONS

A. Flow meters are to be set up, configured, and calibrated by Journeyman instrumentation technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION

- A. Install primary level sensors and transmitters in accordance with manufacturer's installation instructions and as described herein.
 - 1. Where possible, locate instruments near an access hatch or manway to facilitate testing and maintenance activities.
 - 2. Stilling wells where indicated shall be fabricated from a continuous length of 316SS pipe with no seams or joints. The stilling well diameter shall be selected to accommodate the level sensor OD and manufacturer's recommendations.
 - 3. Stilling wells shall have a flanged sensor mounting 1 foot above vessel cover or finished floor level, 1 inch vent hole located above the maximum liquid level, and a flat-cut bottom, refer to standard details for additional detail.
 - 4. Where radar sensors are used in round process vessels, the sensor shall be located at 1/3 of the tank diameter away from the tank wall unless indicated otherwise.
 - 5. Level switches shall be suspended from mounting brackets fabricated from 316SS. Suspend floats from the mounting brackets using J hooks and float manufacturer's cable grips. Provide anti-sway rings for all float cables longer than 6 feet. Maximum spacing of anti-sway rings is 6 feet.

3.03 CALIBRATION

- A. Level meters shall be factory pre-calibrated and calibration shall be verified on site.
- B. Provide printed calibration reports of the factory calibration and as-commissioned in-situ calibration check including all smart device configuration parameters.
 - 1. In line liquid flow meter calibrations shall be verified in-situ using volumetric draw down or similar test approved by the Engineer.
 - 2. Level meters shall be verified in-situ by adjusting the actual liquid level and verifying the measurement against a manual level measurement to a known structural or other fixed reference point such as the vessel bottom or top of access cover.
 - 3. Level switches shall be verified in-situ by adjusting the actual liquid level and verifying the trip point against a manual level measurement to a known structural or other fixed reference point such as the vessel bottom or top of access cover
- C. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

3.05 SCHEDULES

SCHEDULE 1 TO SECTION 40 72 00 LEVEL ELEMENT / TRANSMITTER SCHEDULE				
Tag No.	Description	Process Media	Range (ft)	Materials of Construction
P25-LIT-0102-1	Diversion Box Level Indicating Transmitter	RW	0.0 – 10.0	1,5,8
P25-LIT-0221-1	CIP Tank 1 Level Indicating Transmitter	CSR,CSF	By Vendor	4,7,8
P25-LIT-0222-1	CIP Tank 2 Level Indicating Transmitter	CSR,CSF	By Vendor	4,7,8
P25-LE-0250-1	Backwash Tank Cell 1 Level Element	BWW	0.0 – 12.0	1,5,8
P25-LE-0250-2	Backwash Tank Cell 2 Level Element	BWW	0.0 – 12.0	1,5,8
P25-LE-0250-3	Backwash Tank Cell 3 Level Element	BWW	0.0 – 12.0	1,5,8
P25-LE-0253-1	Chemical Waste Tank Level Element	CSD,SBS	0.0 – 12.0	4,7,8
P25-LT-0302-1	Coagulant Storage Tank 1 Level Transmitter	ACH	0.0 – 15.0	1,5,8
P25-LT-0302-2	Coagulant Storage Tank 2 Level Transmitter	ACH	0.0 – 15.0	1,5,8
P25-LT-0303-1	Sodium Bisulfite Tank Level Transmitter	SBS	0.0 – 15.0	4,7,8
P25-LIT-0241-6A	Backwash Supply Cell 1 Level Indicating Transmitter	UFF	0.0 – 15.0	4,7,8
P25-LIT-0241-6B	Backwash Supply Cell 2 Level Indicating Transmitter	UFF	0.0 – 15.0	4,7,8
P25-LIT-0305-1	LOX Storage Tank Level Indicating Transmitter	LOX	By Vendor	1,5,8
P25-LIT-0401-1	Clearwell Cell 1 Level Indicating Transmitter	OZW	0.0 – 23.0	1,5,8
P25-LIT-0402-1	Clearwell Cell 2 Level Indicating Transmitter	OZW	0.0 – 23.0	1,5,8
Flange Material 1. Carbon Steel 2. 304 Stainless Steel 3. 316 Stainless Steel 4. PVC				
Flange Rating 5. ANSI 150 6. ANSI 300 7. ANSI B16				
Hardware Material 8. 316 Stainless Steel				

**SCHEDULE 2 TO SECTION 40 72 00
LEVEL SWITCH SCHEDULE**

Tag No.	Description	Process Media	Materials of Construction																				
P25-LSH-0250-1	Backwash Tank Cell 1 High Level Switch	BWW	1,5,8																				
P25-LSH-0250-2	Backwash Tank Cell 2 High Level Switch	BWW	1,5,8																				
P25-LSH-0250-3	Backwash Tank Cell 3 High Level Switch	BWW	1,5,8																				
P25-LSH-0253-1	Chemical Waste Tank High Level Switch	CSD,SBS	4,7,8																				
P25-LSH-0302-0	Sump High Level Switch	DR	1,5,8																				
P25-LSH-0302-1	Coagulant Storage Tank 1 High Level Switch	ACH	1,5,8																				
P25-LSH-0302-2	Coagulant Storage Tank 2 High Level Switch	ACH	1,5,8																				
P25-LSH-0303-1	Sodium Bisulfite Tank High Level Switch	SBS	4,7,8																				
P25-LSH-0303-2	Sump High Level Switch	DR	1,5,8																				
P25-LSH-0240-1	Backwash Supply Cell 1 High Level Switch	UFF	4,7,8																				
P25-LSH-0240-2	Backwash Supply Cell 2 High Level Switch	UFF	4,7,8																				
P25-LSH-0403-1	Emergency Overflow Box Level Switch	FW	1,5,8																				
P25-LSH-0401-1	Emergency Overflow Trough High Level Switch	OZW	1,5,8																				
P25-LSH-0403-2	Drain Vault High Level Switch	SPD	8																				
P25-LSH-0410-1	High Service Pump High Level Switch	FW	8																				
P25-LSH-0407-1	Sump Pump High Level Switch	SPD	8																				
P25-LSHH-0419-1	Transmission Pipeline Valve Vault High Level Switch	DR	8																				
<table border="0"> <tr> <td><u>Flange Material</u></td><td><u>Flange Rating</u></td><td><u>Hardware Material</u></td><td></td></tr> <tr> <td>1. Carbon Steel</td><td>5. ANSI 150</td><td>8. 316 Stainless Steel</td><td></td></tr> <tr> <td>2. 304 Stainless Steel</td><td>6. ANSI 300</td><td></td><td></td></tr> <tr> <td>3. 316 Stainless Steel</td><td>7. ANSI B16</td><td></td><td></td></tr> <tr> <td>4. PVC</td><td></td><td></td><td></td></tr> </table>				<u>Flange Material</u>	<u>Flange Rating</u>	<u>Hardware Material</u>		1. Carbon Steel	5. ANSI 150	8. 316 Stainless Steel		2. 304 Stainless Steel	6. ANSI 300			3. 316 Stainless Steel	7. ANSI B16			4. PVC			
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3. 316 Stainless Steel	7. ANSI B16																						
4. PVC																							

END OF SECTION

SECTION 40 73 00

PRESSURE, STRAIN, AND FORCE MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide pressure, strain, and force measurement instrumentation as specified in this section and in compliance with Section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES

- A. A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Submit shop drawings for each specified instrument together with a completed Instrument Data Sheet in accordance with ISA S20 standard.
 - 1. Each instrumentation submittal shall include a copy of the respective specification section marked up to show compliance or non-compliance with specified requirements. Provide written justification for any non-compliance features.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

1.07 WARRANTY

- A. As specified in Section 01 78 36.

PART 2 - PRODUCTS

2.01 PRESSURE AND DIFFERENTIAL PRESSURE GAUGES

- A. Pressure gauges provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
 - 1. Each pressure gauge shall be tagged in accordance with the Instrumentation List and as shown on the P&ID and HVAC Schematic drawings.
 - 2. Liquid filled type.
 - 3. Helical wound bourdon tube, Inconel X-750.
 - 4. Welded parts: Type 316 stainless steel.
 - 5. Bearings: Precision Sapphire Type.
 - 6. 1/2-inch NPT bottom male thread connection.

7. Accuracy: 1/2 percent of scale range. Provide gauges with operating pressure at the midpoint of the scale range.
 8. 4-1/2-inch diameter with ABS plastic case.
 9. Provide external adjustment.
 10. Pipe and Fittings: Schedule 5 Pressfit or Schedule 40 threaded or socket welded, Type 316L stainless steel.
 11. Pump Suction Gauges: Provide gauges with range to cover both the normal operating range and the range of pressures that will result from flushing.
 12. Pump Discharge Gauges: Provide liquid-filled gauges with range to cover the normal operating range, above the pump shutoff head and the range of pressures that will result from flushing.
 13. Seal Water Gauges: Provide gauges with range to cover both the normal operating range and the range of pressures that will result from flushing.
 14. Double Wall Stainless Steel Expansion Joint Gauges: Provide gauges with ranges to suit process line pressure as specified and indicated for the service specified in the Process Piping Schedule.
- B. Pipe and fittings: Type 316L stainless steel, provide as specified herein.
- C. Ball valves: General service stainless steel ball valves in accordance with Section 40 23 13.01.
- D. Pressure Sensor Rings:
1. 1-inch and Larger: Provide sensor/isolators that fit inside the bolt circle of 150-lb (Class 150) or 300-lb (Class 300) ANSI flanges as required.
 2. 3/4-inch and Smaller: Provide sensor/isolators full flange or threaded as specified and indicated. For chemical system provide full flange, threaded connections are not acceptable.
 3. Face to face length of the sensor: Conform to Specification MSS-SP67.
 4. Type: Flow through design with flexible sleeve around full circumference. The center section shall have a cavity behind the sleeve filled with silicone fluid to transfer pressure to the gauge.
 5. Rigidly support all pressure instruments by a post at least 7/8 inch diameter welded to the isolator. On sensor rings with more than one instrument, provide all connections 1/2-inch NPT as a minimum, 1/4-inch NPT fittings are not acceptable.

6. Provide sensor/isolator rings that do not have any fill plugs or valves that can be inadvertently removed with the resultant loss of fill fluid. Pressure sensor/isolators using valves are not acceptable.
7. Provide liquid filled sensor/isolators permanently vacuum sealed at the factory with a modular seal consisting of a membrane and needle fitting to allow removal and replacement of pressure instruments without compromising the vacuum fill. Sensor/isolators using valves are not acceptable.
8. Provide the needle fitting with both 1/4-inch NPT(F) threads and 1/2-inch NPT(M) threads.
9. Provide the pressure sensor/isolator capable of operating under pressure with all pressure instruments removed with no loss of fill fluid. Provide an integral block valve, separate isolation valves are not acceptable.
10. Attach pressure instruments to the isolator with a hand tightened lock ring.
11. It shall be possible to remove or attach pressure instruments to the isolator without requiring the use of any tools.
12. Permanently fill the pressure sensor with high viscosity silicone instrument oil to damp out surges or pressure spikes without the requirement for a separate snubber.
13. Pressure rating: 200 psi minimum for all lines tested at 150 psi or less and 600 psi minimum per lines tested above 150 psi.
14. Materials:
 - a. Pressure sensor/isolator rings: Provide materials suitable for the service conditions specified and indicated, at a minimum provide the following:

Service	Body & Plates	Sleeve
Water	Type 316L Stainless Steel	Natural Rubber
Wastewater	Type 316L Stainless Steel	Natural Rubber
Sludge	Type 316L Stainless Steel	Natural Rubber
Scum	Type 316L Stainless Steel	Natural Rubber
Septage	Type 316L Stainless Steel	Natural Rubber
Grit	Type 316L Stainless Steel	Natural Rubber
Sodium Hypochlorite	Titanium	EPDM
Sodium Bisulfite	Type 316L Stainless Steel	EPDM
Sodium Hydroxide	Type 316L Stainless Steel	EPDM
Ferric Chloride	Kynar Coated Steel	EPDM
Potassium Permanganate	Type 316L Stainless Steel	Natural Rubber
Lime	Type 316L Stainless Steel	Natural Rubber
Polymer	Type 316L Stainless Steel	Viton
Bioxide	Type 316L Stainless Steel	Buna-N
Methanol	Type 316L, Stainless Steel	Viton Type F

E. Suitable manufacturers of pressure gauges and accessories, include:

1. Ashcroft.
2. U.S. Gauge, Division of Ametek, Inc.
3. Wika.

2.02 GAUGE PRESSURE TRANSMITTERS

A. Gauge pressure transmitters provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.

1. Each gauge pressure transmitter shall be tagged in accordance with the Instrumentation List and as shown on the P&ID and HVAC Schematic drawings.
2. Gauge pressure transmitters shall be suitable for 24VDC loop power supply and shall have an accuracy of plus or minus 0.5 percent of calibrated span or better.
3. The transmitter shall have a local display scaled in engineering units.
4. Output shall include 4-20maDC loop powered analog.
5. All gauge pressure transmitters shall be supplied with specified process connections and/or valve manifold to facilitate the measurement, maintenance and calibration activities.
6. Provide diaphragm seals where indicated and fit for the process being measured.

B. The transmitter, and related ancillaries shall have environmental ratings suitable for their respective process areas. In no case shall the transmitter environmental rating be less than NEMA 4X.

C. Suitable manufacturers of gauge pressure transmitters include:

1. Siemens
2. Endress+Hauser
3. Rosemount

2.03 DIFFERENTIAL PRESSURE TRANSMITTERS

A. Differential pressure transmitters provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.

1. Each differential pressure transmitter shall be tagged in accordance with the Instrumentation Index and as shown on the P&ID and HVAC Schematic drawings.

2. Differential pressure transmitters shall be suitable for 24VDC loop power supply and shall have an accuracy of plus or minus 0.5 percent of calibrated span or better.
 3. The transmitter shall have a local display scaled in engineering units.
 4. Output shall include 4-20maDC loop powered analog.
 5. All differential pressure transmitters shall be supplied with specified process connections and/or valve manifold to facilitate the measurement, maintenance and calibration activities.
- B. The transmitter, and related ancillaries shall have environmental ratings suitable for their respective process areas. In no case shall the transmitter environmental rating be less than NEMA 4X.
- C. Suitable manufacturers of differential pressure transmitters include:
1. Siemens
 2. Endress+Hauser
 3. Rosemount

2.04 PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

- A. Pressure and differential pressure switches provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
1. Each pressure and differential pressure switch shall be tagged in accordance with the Instrumentation List and as shown on the P&ID and HVAC Schematic drawings.
 2. Pressure and differential pressure switches shall have a setting accuracy of plus or minus 0.5 percent of calibrated range or better.
 3. Deadband shall be 10 percent of set point or less.
 4. Select switch adjustable range such that the maximum process pressure is 1/2 to 2/3 of maximum range.
 5. Pressure and differential pressure switches shall have SPDT contacts rated 3A @ 120 VAC. Switches shall also be rated for 24 VDC where indicated and applicable.
 6. Pressure switches shall have 1/2 inch NPT stem mounting.
 7. Wetted parts and movement shall be 316SS with a corrosion resistant case.
 8. Provide pressure gauges with factory assembled and filled diaphragm seals or line size pressure sensors where specified.

9. All pressure switches, with or without diaphragm seals shall be supplied with a 316SS block and bleed manifold to facilitate maintenance and calibration activities.
 - B. The switch enclosure, cabling and related ancillaries shall have environmental ratings suitable for their respective process areas. In no case shall the switch, or cabling environmental rating be less than NEMA 4X.
 - C. Suitable manufacturers of pressure switches include:
 1. Ashcroft, B Series Type 400
 2. United Electric, 400 Series
 3. ASCO, S-Series
- 2.05 DIFFERENTIAL PRESSURE GAGE AND SWITCH
- A. Service: Air and non-combustible compatible gases.
 - B. Combination differential pressure gage and switch, diaphragm type.
 - C. The differential pressure gage and switch shall be tagged in accordance with the Instrumentation List and as shown on the P&ID.
 - D. Design:
 1. Temperature Rating (-40°F to 200°F).
 2. Include weatherproof housing, NEMA 4X or greater.
 3. Silver or tantalum diaphragms or approved-equal.
 4. Liquid fluorocarbon oil filling.
 5. 0-inch to 25-inch W.C. pressure rating.
 6. Low setpoint at 1 1/2-inch W.C.
 7. Pressure Switch SPDT contacts rated 1A @ 120 VAC and pressure switch shall be rated for 30 VDC where indicated and applicable.
 8. Electrical Connections shall be 1/2-inch NPT.
 - E. Acceptable manufacturers of differential pressure gage and switches include:
 1. Dwyer
 2. Approved equal

2.06 DIAPHRAGM SEALS AND LINE SIZE PRESSURE SENSORS

- A. Diaphragm seals provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
 - 1. Diaphragm seals shall be constructed of 316SS with an elastomeric diaphragm and fill fluid to provide chemical seal from the process fluid.
 - 2. The elastomer sensing element and fill fluid shall be selected for chemical and temperature resistance to the process fluid.
 - 3. Acceptable manufacturers for diaphragm seals include:
 - a. Ashcroft: Diaphragm Seal Type 200
 - b. Wika
 - c. Approved equal
- B. Line size pressure sensors provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
 - 1. Line size pressure sensors shall be constructed of 316SS with an elastomer sensing element providing 360 degree line-size non-clogging pressure sensing.
 - 2. The elastomer sensing element and fill fluid shall be selected for chemical and temperature resistance to the process fluid.
 - 3. Acceptable manufacturers for line size pressure sensors include:
 - a. Red Valve: Red Valve Pressure Sensor Series 40/42
 - b. Wika Type 918
 - c. Approved equal
- C. All diaphragm chemical seals and line size pressure sensors shall be factory filled and assembled with specified gauges, switches, and/or transmitters.

2.07 PRESSURE INSTRUMENT MANIFOLDS

- A. Pressure instrument Block and Bleed, 3 Valve, and 5 Valve manifolds provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
 - 1. Where specified, manifolds for pressure instrument impulse lines shall be constructed of 316SS.

2. Block and bleed style manifolds shall be used where specified for pressure gauges, pressure switches, gauge pressure transmitters, and absolute pressure transmitters.
3. 3 Valve, or 5 Valve manifolds shall be used where specified for differential pressure transmitters.
4. Acceptable manufacturers for instrument manifolds include:
 - a. Siemens
 - b. Endress + Hauser
 - c. Rosemount
 - d. Anderson Greenwood

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. Pressure instruments and sensors are to be installed, set up, configured, and calibrated by Journeyman instrumentation technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION

- A. Install primary pressure gauges, sensors, and transmitters in accordance with manufacturer's installation instructions and as described herein.
 1. Dials and readouts shall be located and positioned where the dial or readout can be easily read from adjacent walkway or platform to facilitate operation, testing, and maintenance activities.
 2. Locate sensors and instruments as close as possible to the measurement point to minimize the use of impulse tubing.
 3. Where impulse tubing is required, impulse tubing shall be 1/4 inch 316SS with Swagelok tube fittings.
 4. For air or gas applications, the impulse line shall generally be sloped down to the process tap location to prevent condensate buildup in the impulse line. Where this is not possible, provide a condensate drip pot with manual drain valve at the low point in the impulse line.
 5. For liquid applications, the impulse line shall generally be sloped up to the process tap location to prevent air buildup in the impulse line. Where this is not possible, provide an automatic air release valve at the high point in the impulse line.

6. Install impulse tubing with a continuous slope from the instrument to the process tapping and avoid high or low spots in the tubing run.
7. Impulse tubing shall be continuously supported for mechanical protection and to prevent sagging.

3.03 CALIBRATION

- A. Pressure instruments shall be factory pre-calibrated and calibration shall be verified in-situ.
- B. Provide printed calibration reports of the factory calibration and as-commissioned in-situ calibration check including all smart device configuration parameters.
 1. Pressure gauges shall be verified on site using a certified test gauge, pressure calibrator, or equivalent test approved by the Engineer.
 2. Pressure transmitters shall be verified in-situ using a certified pressure calibrator.
- C. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

3.05 SCHEDULES

SCHEDULE 1 TO SECTION 40 73 00 PRESSURE INDICATOR SCHEDULE							
Tag No.	DWG No.	Description	Process Media	Process Temp F	Scale Range PSIG	Seal Type	Special Requirements
P25-PI-0201-2A	10-X602	STR-0201-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0201-2B	10-X602	STR-0201-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0202-2A	10-X602	STR-0202-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0202-2B	10-X602	STR-0202-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0203-2A	10-X602	STR-0203-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0203-2B	10-X602	STR-0203-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0204-2A	10-X603	STR-0204-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0204-2B	10-X603	STR-0204-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0205-2A	10-X603	STR 0205-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0205-2B	10-X603	STR 0205-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0206-2A	10-X604	STR-0206-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0206-2B	10-X604	STR-0206-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0207-2A	10-X603	STR-0207-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0207-2B	10-X603	STR-0207-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0208-2A	10-X604	STR-0208-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0208-2B	10-X604	STR-0208-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0209-2A	10-X604	STR-0209-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0209-2B	10-X604	STR-0209-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0210-2A	10-X605	STR-0210-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0210-2B	10-X605	STR-0210-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0211-2A	10-X605	STR-0211-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0211-2B	10-X605	STR-0211-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0212-2A	10-X606	STR-0212-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0212-2B	10-X606	STR-0212-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0213-2A	10-X605	STR-0213-2 Suction Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0213-2B	10-X605	STR-0213-2 Discharge Pressure Indicator	UFI	36-80	0-100	N/A	N/A
P25-PI-0251-1	10-X615	PMP-0251-1 Discharge Pressure Indicator	BWR	36-80	0-30	Diaphragm	N/A
P25-PI-0251-2	10-X615	PMP-0251-2 Discharge Pressure Indicator	BWR	36-80	0-30	Diaphragm	N/A
P25-PI-0251-3	10-X615	PMP-0251-3 Discharge Pressure Indicator	BWR	36-80	0-30	Diaphragm	N/A
P25-PI-0251-4	10-X615	PMP-0251-4 Discharge Pressure Indicator	BWR	36-80	0-30	Diaphragm	N/A
P25-PI-0252-1	10-X615	PMP-0252-1 Discharge Pressure Indicator	SLG	36-80	0-60	Diaphragm	N/A
P25-PI-0252-2	10-X615	PMP-0252-1 Discharge Pressure Indicator	SLG	36-80	0-60	Diaphragm	N/A
P25-PI-0253-1	10-X616	PMP-0253-1 Discharge Pressure Indicator	DR	36-80	0-60	Diaphragm	N/A

SCHEDULE 1 TO SECTION 40 73 00 PRESSURE INDICATOR SCHEDULE							
Tag No.	DWG No.	Description	Process Media	Process Temp F	Scale Range PSIG	Seal Type	Special Requirements
P25-PI-0253-2	10-X616	PMP-0253-2 Discharge Pressure Indicator	DR	36-80	0-60	Diaphragm	N/A
P25-PI-0231-7	10-X617	TNK-0231-7 Pressure Indicator	AHP	*	*	*	*
P25-PI-0232-7	10-X617	TNK-0232-7 Pressure Indicator	AHP	*	*	*	*
P25-PI-0301-8	10-X619	PMP-0301-8 Discharge Pressure Indicator	UFF	36-80	0-85	Diaphragm	N/A
P25-PI-0301-9	10-X619	PMP-0301-9 Discharge Pressure Indicator	UFF	36-80	0-85	Diaphragm	N/A
P25-PI-0301-10	10-X619	PMP-0301-10 Discharge Pressure Indicator	UFF	36-80	0-135	Diaphragm	N/A
P25-PI-0301-11	10-X619	PMP-0301-11 Discharge Pressure Indicator	UFF	36-80	0-135	Diaphragm	N/A
P25-PI-0301-12A	10-X619	INJ-0301-12 Suction Pressure Indicator	UFF	36-80	0-70	Diaphragm	N/A
P25-PI-0301-12B	10-X619	INJ-0301-12 Discharge Pressure Indicator	CLS	36-80	0-5	Diaphragm	N/A
P25-PI-0301-13A	10-X619	INJ-0301-13 Suction Pressure Indicator	UFF	36-80	0-70	Diaphragm	N/A
P25-PI-0301-13B	10-X619	INJ-0301-13 Discharge Pressure Indicator	CLS	36-80	0-5	Diaphragm	N/A
P25-PI-0301-14A	10-X619	INJ-0301-14 Suction Pressure Indicator	UFF	36-80	0-125	Diaphragm	N/A
P25-PI-0301-14B	10-X619	INJ-0301-14 Discharge Pressure Indicator	CLS	36-80	0-30	Diaphragm	N/A
P25-PI-0301-15A	10-X619	INJ-0301-15 Suction Pressure Indicator	UFF	36-80	0-125	Diaphragm	N/A
P25-PI-0301-15B	10-X619	INJ-0301-15 Discharge Pressure Indicator	CLS	36-80	0-30	Diaphragm	N/A
P25-DPI-0301-16	10-X619	TNK-0301-16 Differential Pressure Indicator	*	*	*	*	*
P25-PI-0302-1	10-X621	PMP-0302-1 Discharge Pressure Indicator	ACH	*	*	Diaphragm	*
P25-PI-0302-2	10-X621	PMP-0302-2 Discharge Pressure Indicator	ACH	*	*	Diaphragm	*
P25-PI-0302-3	10-X621	PMP-0302-3 Discharge Pressure Indicator	ACH	*	*	Diaphragm	*
P25-PI-0303-1	10-X622	PMP-0303-1 Discharge Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0303-2	10-X622	PMP-0303-2 Discharge Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0303-3	10-X622	PMP-0303-3 Discharge Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0303-4	10-X622	PMP-0303-4 Discharge Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0303-5	10-X622	PMP-0303-5 Discharge Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0303-1A	10-X622	Sodium Bisulfite Solution to Clearwell Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0303-3A	10-X622	Sodium Bisulfite Solution to Clearwell Pressure Indicator	SBS	*	*	Diaphragm	*
P25-PI-0304-1	10-X623	Citric Acid Pump 1 Discharge Pressure Indicator	CIT	*	*	Diaphragm	*
P25-PI-0304-2	10-X623	Citric Acid Pump 2 Discharge Pressure Indicator	CIT	*	*	Diaphragm	*
P25-PI-0304-3	10-X623	Citric Acid Pumps Inlet Air Header Pressure Indicator	AHP	*	*	Diaphragm	*
P25-PI-0310-1	10-X623	NaClO Pump 1 Discharge Pressure Indicator	SH	*	*	Diaphragm	*
P25-PI-0310-2	10-X623	NaClO Pump 2 Discharge Pressure Indicator	SH	*	*	Diaphragm	*
P25-PI-0310-3	10-X623	NaClO Pumps Inlet Air Header Pressure Indicator	AHP	*	*	Diaphragm	*
P25-PI-0241-1	10-X625	PMP-0241-1 Discharge Pressure Indicator	BWS	36-80	0-100	Diaphragm	*
P25-PI-0241-2	10-X625	PMP-0241-2 Discharge Pressure Indicator	BWS	36-80	0-100	Diaphragm	*
P25-PI-0241-3	10-X625	PMP-0241-3 Discharge Pressure Indicator	BWS	36-80	0-100	Diaphragm	*
P25-PI-0307-1	10-X626	TNK-0307-1 Pressure Indicator	*	*	*	*	*

SCHEDULE 1 TO SECTION 40 73 00 PRESSURE INDICATOR SCHEDULE							
Tag No.	DWG No.	Description	Process Media	Process Temp F	Scale Range PSIG	Seal Type	Special Requirements
P25-DPI-0306-2A	10-X626	FLT-0306-2 Differential Pressure Indicator	GOX	*	*	*	*
P25-DPI-0306-3A	10-X626	SK-0306-1 Differential Pressure Indicator	GOX	*	*	*	*
P25-PI-0903-3A	10-X627	Ozone Chillers Cooling Water Return Pressure Indicator	CWR	*	*	*	*
P25-PI-0903-3B	10-X627	Ozone Chillers Cooling Water Supply Pressure Indicator	CWS	*	*	*	*
P25-PI-0308-5A	10-X628	SK-0308-6 Ozone Pressure Indicator	OZG	*	*	*	*
P25-PI-0308-5B	10-X628	SK-0308-6 Discharge Pressure Indicator	OZW	*	*	*	*
P25-PI-0308-6A	10-X628	PMP-0308-6 Suction Pressure Indicator	MW	*	*	*	*
P25-PI-0308-6B	10-X628	PMP-0308-6 Discharge Pressure Indicator	MW	*	*	*	*
P25-PI-0308-7A	10-X628	PMP-0308-7 Suction Pressure Indicator	MW	*	*	*	*
P25-PI-0308-7B	10-X628	PMP-0308-7 Discharge Pressure Indicator	MW	*	*	*	*
P25-PI-0417-1	20-X602	HSPS Discharge Header Pressure Indicator	FW	36-80	0-200	Diaphragm	N/A
* By Vendor							

SCHEDULE 2 TO SECTION 40 73 00 PRESSURE INDICATING TRANSMITTER SCHEDULE							
Tag No.	DWG No.	Description	Process Media	Process Temp F	Scale Range PSI	Seal Type	Special Requirements
P25-PIT-0303-1	10-X601	Raw Water Influent Pressure Indicating Transmitter	RW	36-80	0-15	Diaphragm	*
P25-PIT-0221-2	10-X612	CIP Skid 1 Discharge Pressure Indicating Transmitter	CSR	*	*	*	*
P25-PIT-0221-4	10-X612	PMP-0221-2 Discharge Pressure Indicating Transmitter	CSF	*	*	*	*
P25-PIT-0226-1	10-X612	CIP Skid 1 Inlet Air Pressure Indicating Transmitter	AHP	*	*	*	*
P25-PIT-0222-2	10-X613	CIP Skid 2 Discharge Pressure Indicating Transmitter	CSR	*	*	*	*
P25-PIT-0222-4	10-X613	PMP-0222-2 Discharge Pressure	CSF	*	*	*	*
P25-PIT-0230-1	10-X613	CIP Skid 2 Inlet Air Pressure Indicating Transmitter	AHP	*	*	*	*
P25-PIT-0234-1	10-X617	Air Supply Header Air Pressure Indicating Transmitter	AHP	*	*	*	*
P25-PIT-0305-1	10-X626	TNK-0305-1 Pressure Indicating Transmitter	LOX	*	*	*	*
P25-PIT-0305-1	10-X626	VAP-0305-1 Discharge Pressure Indicating Transmitter	GOX	*	*	*	*
P25-PIT-0305-2	10-X626	VAP-0305-2 Discharge Pressure Indicating Transmitter	GOX	*	*	*	*
P25-PIT-0306-1B	10-X626	SK-0306-1 Inlet Pressure Indicating Transmitter	GOX	*	*	*	*
P25-PIT-0306-3A	10-X626	SK-0306-1 Outlet Pressure Indicating Transmitter	GOX	*	*	*	*
P25-PIT-0308-6A	10-X628	SK-0308-6 Water Inlet Pressure Indicating Transmitter	MW	*	*	*	*
P25-PIT-0308-6B	10-X628	PMP-0308-6 Discharge Pressure Indicating Transmitter	MW	*	*	*	*
P25-PIT-0308-7B	10-X628	PMP-0308-7 Discharge Pressure Indicating Transmitter	MW	*	*	*	*

**SCHEDULE 2 TO SECTION 40 73 00
PRESSURE INDICATING TRANSMITTER SCHEDULE**

Tag No.	DWG No.	Description	Process Media	Process Temp F	Scale Range PSI	Seal Type	Special Requirements
P25-PIT-0403-1A	20-X601	West Clearwell Drain Pressure Indicating Transmitter	DR	36-80	0-30	Diaphragm	N/A
P25-PIT-0403-1A	20-X601	East Clearwell Drain Pressure Indicating Transmitter	DR	36-80	0-30	Diaphragm	N/A
P25-PIT-0417-1	20-X602	HSPS Discharge Header Pressure Indicating Transmitter	FW	36-80	0-200	Diaphragm	N/A
P25-DPIT-0417-1	20-X602	Surge Bladder 1 Differential Pressure Indicating Transmitter	FW	36-80	*	*	*
P25-DPIT-0417-2	20-X602	Surge Bladder 2 Differential Pressure Indicating Transmitter	FW	36-80	*	*	*
P25-PIT-0401-1	20-X603	SK-0401-2 Inlet Pressure Indicating Transmitter	OZG	*	*	*	*
P25-PIT-0401-3	20-X603	SK-0401-3 Pressure Indicating Transmitter	OZG	*	*	*	*
P25-PIT-0402-1	20-X603	SK-0402-2 Inlet Pressure Indicating Transmitter	OZG	*	*	*	*
P25-PIT-0402-3	20-X603	SK-0401-3 Pressure Indicating Transmitter	OZG	*	*	*	*

* By Vendor

**SCHEDULE 3 TO SECTION 40 73 00
PRESSURE SWITCH SCHEDULE**

Tag No.	DWG No.	Description	Process Media	Process Temp F	Set Point PSI	Seal Type	Special Requirements
P25-PSL-0302-5	10-X601	PMP-0302-5 Suction Pressure Switch Low	RW	36-80	1.5	Diaphragm	N/A
P25-PSL-0302-6	10-X601	PMP-0302-6 Suction Pressure Switch Low	RW	36-80	1.5	Diaphragm	N/A
P25-PSL-0201-1	10-X602	PMP-0201-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0201-2	10-X602	STR-0201-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0202-1	10-X602	PMP-0202-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0202-2	10-X602	STR-0202-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0203-1	10-X602	PMP-0203-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0203-2	10-X602	STR-0203-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0204-1	10-X603	PMP-0204-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0204-2	10-X603	STR-0204-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0205-1	10-X603	PMP-0205-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0205-2	10-X603	STR-0205-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0206-1	10-X604	PMP-0206-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0206-2	10-X604	STR-0206-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0207-1	10-X603	PMP-0207-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0207-2	10-X603	STR-0207-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0208-1	10-X604	PMP-0208-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0208-2	10-X604	STR-0208-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*

**SCHEDULE 3 TO SECTION 40 73 00
PRESSURE SWITCH SCHEDULE**

Tag No.	DWG No.	Description	Process Media	Process Temp F	Set Point PSI	Seal Type	Special Requirements
P25-PSL-0209-1	10-X604	PMP-0209-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0209-2	10-X604	STR-0209-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0210-1	10-X605	PMP-0210-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0210-2	10-X605	STR-0210-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0211-1	10-X605	PMP-0211-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0211-2	10-X605	STR-0211-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0212-1	10-X606	PMP-0212-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0212-2	10-X606	STR-0212-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0213-1	10-X605	PMP-0213-1 Suction Pressure Switch Low	RW	36-80	2.75	Diaphragm	N/A
P25-DPSH-0213-2	10-X605	STR-0210-2 Differential Pressure Switch High	UFI	36-80	*	N/A	*
P25-PSL-0251-1	10-X615	PMP-0251-1 Suction Pressure Switch Low	BWR	36-80	0.5	Diaphragm	N/A
P25-PSL-0251-2	10-X615	PMP-0251-2 Suction Pressure Switch Low	BWR	36-80	0.5	Diaphragm	N/A
P25-PSL-0251-3	10-X615	PMP-0251-3 Suction Pressure Switch Low	BWR	36-80	0.5	Diaphragm	N/A
P25-PSL-0251-4	10-X615	PMP-0251-4 Suction Pressure Switch Low	BWR	36-80	0.5	Diaphragm	N/A
P25-PSL-0253-1	10-X616	PMP-0253-1 Suction Pressure Switch Low	DR	36-80	0.5	Diaphragm	N/A
P25-PSL-0253-2	10-X616	PMP-0253-2 Suction Pressure Switch Low	DR	36-80	0.5	Diaphragm	N/A
P25-PSL-0231-7	10-X617	TNK-0231-7 Pressure Switch Low	AHP	*	*	*	*
P25-PSH-0231-7	10-X617	TNK-0231-7 Pressure Switch High	AHP	*	*	*	*
P25-PSL-0232-7	10-X617	TNK-0232-7 Pressure Switch Low	AHP	*	*	*	*
P25-PSH-0232-7	10-X617	TNK-0232-7 Pressure Switch High	AHP	*	*	*	*
P25-PSH-0301-3	10-X618	Chlorine Gas Header Pressure Switch High	CLV	*	*	*	*
P25-PSH-0301-4	10-X618	CL-0301-4 Discharge Pressure Switch High	CLV	*	*	*	*
P25-PSH-0301-5	10-X618	CL-0301-5 Discharge Pressure Switch High	CLV	*	*	*	*
P25-PSH-0301-6	10-X618	CL-0301-6 Discharge Pressure Switch High	CLV	*	*	*	*
P25-PSH-0301-7	10-X618	CL-0301-7 Discharge Pressure Switch High	CLV	*	*	*	*
P25-DPS-0301-16	10-X620	TNK-0301-16 Differential Pressure Switch High	*	*	*	*	*
P25-PSL-0241-1	10-X625	PMP-0241-1 Suction Pressure Switch Low	BWS	36-80	1.0	Diaphragm	N/A
P25-PSL-0241-2	10-X625	PMP-0241-2 Suction Pressure Switch Low	BWS	36-80	1.0	Diaphragm	N/A
P25-PSL-0241-3	10-X625	PMP-0241-3 Suction Pressure Switch Low	BWS	36-80	1.0	Diaphragm	N/A
P25-PSL-0307-1	10-X626	TNK-0307-1 Pressure Switch Low	*	*	*	*	*
P25-PSH-0307-1	10-X626	TNK-0307-1 Pressure Switch High	*	*	*	*	*
P25-DPSH-0307-2A	10-X626	SK-0307-1 Filter Differential Pressure Switch High	*	*	*	*	*
P25-DPSH-0307-2B	10-X626	SK-0307-1 Filter Differential Pressure Switch High	*	*	*	*	*
P25-DPSH-0307-2C	10-X626	SK-0307-1 Filter Differential Pressure Switch High	*	*	*	*	*
P25-PSH-0308-6B	10-X628	PMP-0308-6 Discharge Pressure Switch High	*	*	*	*	*
P25-PSH-0308-7B	10-X628	PMP-0308-7 Discharge Pressure Switch High	*	*	*	*	*

SCHEDULE 3 TO SECTION 40 73 00 PRESSURE SWITCH SCHEDULE							
Tag No.	DWG No.	Description	Process Media	Process Temp F	Set Point PSI	Seal Type	Special Requirements
P25-PSH-0411-1	20-X602	PMP-0411-1 Discharge Pressure Switch High	FW	36-80	*	N/A	N/A
P25-PSH-0412-1	20-X602	PMP-0412-1 Discharge Pressure Switch High	FW	36-80	*	N/A	N/A
P25-PSH-0413-1	20-X602	PMP-0413-1 Discharge Pressure Switch High	FW	36-80	*	N/A	N/A
P25-PSH-0414-1	20-X602	PMP-0414-1 Discharge Pressure Switch High	FW	36-80	*	N/A	N/A
P25-PSH-0415-1	20-X602	PMP-0415-1 Discharge Pressure Switch High	FW	36-80	*	N/A	N/A
P25-PSL-0416-1	20-X602	HSPS Suction Header Pressure Switch Low	FW	36-80	*	N/A	N/A
P25-DPS-0401-1	20-X603	SK-0401-2 Differential Pressure Switch	OZG	*	*	*	*
P25-DPS-0402-1	20-X603	SK-0402-2 Differential Pressure Switch	OZG	*	*	*	*
* By Vendor							

END OF SECTION

SECTION 40 74 00

TEMPERATURE MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide temperature measurement instrumentation as specified in this section and in compliance with Section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.
- D. This specification covers process temperature measurement. For HVAC temperature measurement refer to Division 23.

1.02 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Operation and Maintenance Data:
 - 1. Operation and maintenance manuals shall be specific to equipment purchased and crossing out of non-applicable items is not acceptable.
 - 2. Comply with requirements of Section 01 78 23.

1.03 SPARE PARTS

- A. Comply with requirements specified in Section 01 61 00.
- B. Provide a list of recommended spare parts for the first year of operation and for the first five years of operation, including a price list and location of the nearest facility from which all spare parts can be obtained.

1.04 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.05 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

1.06 WARRANTY

- A. As specified in Section 01 78 36.

PART 2 - PRODUCTS

2.01 RTD SENSOR

- A. RTD sensors provided for this project shall all be sourced from the same manufacturer and in compliance with this specification.
 - 1. Each RTD sensor and temperature indicating transmitter shall be tagged in accordance with the Instrumentation List and as shown on the P&ID and HVAC drawings.
 - 2. The RTD sensor as installed shall 100-ohm platinum and be capable of measuring between 32°C and 120°C with an accuracy of plus or minus 0.5 percent of the installed span.
 - 3. Each RTD shall have a 316 SS thermowell.
 - a. RTD shall be spring loaded in the thermowell to maintain sufficient contact with the thermowell tip.
 - b. Provide weld-o-lets as needed
 - c. Thermowells mounted on process piping shall be sized to extend to the center of the pipe.
 - d. Thermowells mounted on tanks shall be sized to extend 4 inches into the liquid beyond the inside of the tank wall.
 - 4. Indicating transmitters shall be rated NEMA 4X and have an LCD or LED display scaled in engineering units.
 - 5. RTD sensor shall be loop powered with a 4 20 mA output rated for a 500 Ohm load.
 - 6. Where local transmitter displays are not viewable from a standing position without the use of a ladder or a lift, provide a remote mounted indicating transmitter on the wall or separate instrument stand. Coordinate with Engineer for location.
- B. Suitable manufacturers include:
 - 1. Thermo Sensors
 - 2. Endress + Hauser

2.02 DIGITAL TEMPERATURE TRANSMITTER

A. Function: Provide analog output signal directly proportional to sensed temperature.

B. Performance Specifications:

1. Adjustable Range: See Schedules
2. Number of Switches and Setpoints: One.
3. Setpoint Accuracy: 0.5% of full range span.
4. Power Supply: 10-36Vdc loop-power.
5. Outputs:
 - a. Analog: 4-20mA_{dc} isolated.
 - b. Discrete: SPST solid state rated for 600mA @ 120VAC

C. Required Features:

1. Repeatability: 0.1% of full range span.
2. Programmable response time delay: 2 seconds minimum.
3. Programmable for automatic or manual reset.
4. Field adjustable setpoint over full range by means of external touchpad.
5. Display: 0.5" 4-digit (minimum), LCD.
6. Screw type terminals.
7. ½" NPT female process connection.
8. ½" NPT female electrical connection.
9. Temperature sensor element shall be 316SS.
10. NEMA 4X epoxy-coated aluminum enclosure.
11. Programming and data shall be protected by non-volatile EEPROM.
12. Sensor: Provide local sensor unless indicated otherwise on the Drawings.

D. Manufacturers:

1. Endress + Hauser

2. Siemens
3. Emerson Rosemount

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. Temperature sensors are to be set up, configured, and calibrated by Journeyman instrumentation technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION

- A. Install temperature elements and signal converters in accordance with manufacturer's installation instructions.
- B. Thermowells installed in tanks shall be horizontally mounted at a depth to ensure continuous submergence in the fluid.

3.03 FIELD TESTING

- A. Validate the PLC scaling and alarming by injecting a 4-20 mA signal into the PLC terminals with the temperature sensor disconnected.

3.04 TRAINING

- A. Comply with the requirements in Section 01 78 25.
- B. Provide field operation and maintenance instruction.
- C. Coordinate training time with the Engineer and Owner.

3.05 CALIBRATION

- A. Refer to the Schedule 1 for instrument operating conditions, ranges, setpoints, and alarms.
- B. Temperature sensors shall be calibrated on site.
- C. Provide printed calibration reports of the factory calibration and as-commissioned in-situ calibration check including all smart device configuration parameters.
 1. Calibrations shall be verified in-situ using a separate thermal sensor with equal or higher accuracy or similar test approved by the Engineer.
- D. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.06 ADJUSTING

- A. Adjust the calibrated and scaled range for each temperature transmitter as requested during commissioning.

3.07 DEMONSTRATION

- A. Demonstrate RTD accuracy by removing from the installation and applying varying amounts of heat to the probe. Verify the temperature reading with a separate thermal sensor with equal or higher accuracy.

3.08 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

3.09 SCHEDULES

SCHEDULE 1 TO SECTION 40 74 00 TEMPERATURE INDICATING TRANSMITTER SCHEDULE						
Tag No.	DWG No.	Description	Process Media	Range °C	Type	Special Requirements
P25-TIT-0221-1	10-X612	CIP TNK-0221-1 Temperature Indicating Transmitter	CSR	*	*	*
P25-TIT-0222-1	10-X613	CIP TNK-0222-1 Temperature Indicating Transmitter	CSR	*	*	*
P25-TIT-0305-1	10-X626	LOX Vaporizer 1 Discharge Temperature Indicating Transmitter	GOX	*	*	*
P25-TIT-0305-2	10-X626	LOX Vaporizer 2 Discharge Temperature Indicating Transmitter	GOX	*	*	*
P25-TIT-0306-3A	10-X626	GOX Discharge Temperature Indicating Transmitter	GOX	*	*	*
P25-TIT-0418-1A	20-X602	HSPS Discharge Sample Temperature Indicating Transmitter	FW	36-80	Threaded	N/A
P25-TIT-0401-3	20-X603	Ozone Destruction Unit 1 Temperature Indicating Transmitter	OZG	*	*	*
P25-TIT-0401-4	20-X603	Ozone Destruction Unit 1 Temperature Indicating Transmitter	OZG	*	*	*
P25-TIT-0402-3	20-X603	Ozone Destruction Unit 2 Temperature Indicating Transmitter	OZG	*	*	*
P25-TIT-0402-4	20-X603	Ozone Destruction Unit 2 Temperature Indicating Transmitter	OZG	*	*	*
* By Vendor						

END OF SECTION

SECTION 40 75 00

PROCESS LIQUID ANALYTICAL MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide process liquid analytical measurement instrumentation as specified in this section and in compliance with Section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES:

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and Testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Submit shop drawings for each specified instrument together with a completed Instrument Data Sheet in accordance with ISA S20 standard.
 - 1. Each instrumentation submittal shall include a copy of the respective specification section marked up to show compliance or non-compliance with specified requirements. Provide written justification for any non-compliance features.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 PROCESS LIQUID ANALYTICAL INSTRUMENTATION

- A. pH/ORP (Oxidation Reduction Potential) Analyzers
 - 1. Description: Three electrode (process, reference, and ground) differential pH/ORP probe and a microprocessor-based analyzer/transmitter designed to measure pH/ORP of the sample and produce a proportional output signal linear to the pH/ORP.
 - 2. Analyzer
 - a. Number of Sensors: 4
 - b. Number of Analog Outputs: 4
 - c. Display: 4" minimum, color.
 - d. Power: 120V
 - e. Output: 4-20 mA
 - f. Enclosure: NEMA 4X
 - g. Maximum Dimensions: 11" x 13" x 6" (W x H x D)
 - h. Note: Where possible combine multiple sensors/probes on a single analyzer/transmitter.
 - 3. pH Probe
 - a. Type: W-type rod membrane, pH electrode
 - b. Measured: pH
 - c. Probe range: 0 – 14 s.u.
 - d. Slope: 95 – 102%

- e. Stability: < -0.01 s.u. per hour (without calibration)
- f. Reproducibility: < 0.01 s.u
- g. Working electrode: Gold cathode
- h. Counter electrode: SST anode
- i. Reference electrode: silver/silver halide
- j. Temperature range: 41 to 113 degrees F
- k. pH Range: 4-9 s.u.
- l. First polarization time: 120 minutes
- m. Re-polarization time: 30 minutes
- n. Calibration: Manual using DPD
- o. Housing Material: PVC
- 4. Accessories:
 - a. Flow cell: Provide a polycarbonate flow cell and backplate. Provide dual flow cell in instances where two probes are required. Mount using 304 SST hardware.
- 5. Materials
 - a. Sensor
 - 1) Body and salt bridge: PEEK.
 - 2) Junction: Kynar.
 - 3) Process electrode: Glass (pH), glass and platinum (ORP).
 - 4) Ground electrode: Titanium.
 - 5) O-ring seals: Viton.
 - b. Analyzer/Transmitter Enclosure: NEMA 4X.
 - c. Insertion Mounting Assembly: Stainless steel, type 316.
- 6. Ratings and Performance
 - a. Sensor
 - 1) Range: 0 to 14 pH; -1500 to +1500 mV ORP.
 - 2) Sensitivity: +/- 0.01 pH; +/- 0.5 mV ORP.
 - 3) Stability: 0.03 pH; 2mV ORP per 24 hours, non cumulative.
 - 4) Operating temperature: 23 to 158 degrees F.
 - 5) Maximum pressure: 100 psi at 158 degrees.
 - 6) Maximum flow rate: 10 fps.
 - b. Analyzer/Transmitter
 - 1) Repeatability: 0.05% of span.
 - 2) Stability: 0.05% of span for 24 hours, non-cumulative.
 - 3) Analog outputs: 4 to 20 mA isolated.
 - 4) Ambient temperature range: -4 to 104 deg F.
 - 5) Relative humidity: 0 to 95% non-condensing.
 - 6) Input power: 120 V a. c., 35W maximum.
 - 7) Output contacts: 120 V a. c., 5 Amp resistive maximum.
 - 8) Analog outputs: 500 Ohms maximum impedance.
- 7. Product and Manufacturer
 - a. Kuntze Krypton Multi water monitoring system.
 - b. No substitutions

B. Turbidity Analyzer

- 1. Description: Analyzer to monitor turbidity of potable water.

2. Analyzer/Probe
 - a. Number of Sensors: 1
 - b. Number of Analog Outputs: 1
 - c. Power: 120V
 - d. Output: 4-20 mA
 - e. Enclosure: NEMA 4X FRP
 - f. Measured: Turbidity (NTU)
 - g. Probe range: 0-100 NTU
 - h. Accuracy: $\pm 2\%$ of Reading or ± 0.02 NTU from 0 to 40 NTU
 - i. Cycle Time: 5 – 9999 minutes
 - j. Response Time: 15 Seconds from change in turbidity
 - k. Temperature range: 41 to 75 degrees F
 - l. Construction: All non-corrosive materials
 - m. Mounting: Wall or floor stand
3. Accessories:
 - a. Reagents: Provide a sufficient amount of VMO reagent suitable for 12 months of operation at a 5 minute sample cycle. Provide reagent line priming package, reagent and cleaning solution bottle with connection lines, and reagent rack.
4. Other Requirements:
 - a. All wetted parts must be suitable for the intended service conditions.
 - b. Provide field replaceable sensor.
 - c. Supply each probe with 50 feet of cable, with a weatherproof plug on each end for connection to the transmitter. Provide a cover permanently attached to protect the probe when not in use.
 - d. The manufacturer of the analyzer shall furnish initial startup and calibration services when notified by the Contractor that all units are installed, powered and ready for operation.
 - e. Services shall be furnished by the manufacturer to provide instruction to the operating personnel in the operation and maintenance of the analyzer.
 - f. Furnish spare parts for one year of operation including electrolyte, membranes, and junctions.
 - g. Provide suitable 120 VAC sample pump and sample filter.
 - h. Provide one year's supply of calibration solution. Assume weekly calibration.
5. Product and Manufacturer:
 - a. Hach TU5300sc with sc200 controller Or Equal

C. TSS (Total Suspended Solids) Analyzers

1. Particle counter for monitoring 2 to 750 micron diameter particles in water.
2. Performance Requirements
 - a. Particle detection range: 2 to 750 micrometer diameter
 - b. Number of discrete bin sizes: 32

- c. Count limits: 9,999,999 totalized count, updated at end of each count cycle, maximum
 - d. Sample/hold time: 1 second to 24 hours
 - e. Internal light transmittance: 99.0 percent, minimum
3. Certifications
- a. Safety: UL/CSA approved 100-115 V, 50/60 Hz external wall-style power supply or 100-240 V, 50/60 Hz external NEMA-enclosed power supply certified with the instrument to EN 61010-1 (IEC1010-1).
 - b. Immunity: EN 50081-2: 1992 (Generic Immunity Standard) per 89/336/EEC EMC
 - c. Emissions: EN 50081-2 (Generic Emissions Standard) per 89/336/EEC EMC
4. Environmental Requirements
- a. Operational Criteria
 - (1) Sample flow rate: 100 mL/minute
 - (2) Operating temperature: 0 to 50 degrees C (32 to 122 degrees F)
 - (3) Pressure: 65 psig, not more than 1 minute; 55 psig, continuous
5. Equipment Requirements
- a. 100-115 Vac, 60 Hz, power.
 - b. Operates in cumulative/differential counting/transmitting modes.
 - c. Capable of self-timing and can operate as an independent device.
 - d. The sensor, 750 by 750 micrometers, is volumetric and the sensing area is the entire cross-section of the sample flow path.
 - e. Cleaning of the sensor for maintenance can be performed without opening the enclosure.
 - f. Equipped with a field replaceable flow cell that can be installed without special tools.
 - g. Sensors are calibrated per ASTM F 658, using NIST traceable PSL spheres from Duke Scientific and have size resolution of better than 10% at 10 micrometers (per USP 788).

- h. Indicators are provided for power, counting display (6-digit capacity), clean sensor, and alarm.
 - i. 12-bit A/D resolution.
 - j. Sensor/counters can communicate to a data collection system using 4-20mA analog output signals and RS485 serial communications. Particle counts are transmitted in raw, total counts (not normalized to counts/mL).
 - k. Can accept up to eight analog input signals from other measurement devices.
- 6. Standard Components
 - a. Sensor/counter
 - b. Spare sensor cell
 - c. Power supply
 - d. Manual
 - e. Connectors (inlet and outlet): quick disconnect to 1/4-inch OD tubing.
- 7. Accessories
 - a. Flow control: active and passive/manual control devices.
 - b. Analog input/output card.
 - c. Software for filter performance, report generation, communication for standalone operation of direct connection to SCADA system.
 - d. Grab sampling instrument
 - e. Junction box for permanent installation.
- 8. Manufacturers
 - a. Hach 2200 PCX Particle Counter or Equal

D. Residual Chlorine Analyzer

- 1. Description: Amperometric chlorine probe for reagentless free chlorine measurement.
- 2. Analyzer
 - a. Number of Sensors: Up to four (4)

- b. Number of Analog Outputs: Up to four (4)
 - c. Display: 4" minimum, color.
 - d. Power: 120V
 - e. Output: 4-20mA
 - f. Enclosure: NEMA 4X FRP
 - g. Maximum Dimensions: 11" x 13" x 6" (W x H x D)
 - h. Note: Where possible combine multiple sensors/probes on a single analyzer/transmitter.
3. Probe
- a. Type: Membrane covered amperometric three-electrode system
 - b. Measured: Free residual chlorine
 - c. Probe range: 0.05-5 mg/L
 - d. Resolution: 0.01 mg/L
 - e. Reproduction: +/- 5%
 - f. Stability: -1% per month (without calibration)
 - g. Working electrode: Gold cathode
 - h. Counter electrode: SST anode
 - i. Reference electrode: Silver/silver halide
 - j. Temperature range: 41 to 113 degrees F
 - k. pH Range: 4-9 s.u.
 - l. First polarization time: 120 minutes
 - m. Re-polarization time: 30 minutes
 - n. Calibration: Manual using DPD
 - o. Housing Material: PVC
4. Accessories:

- a. Flow cell: Provide a polycarbonate flow cell and backplate. Provide dual flow cell in instances where two probes are required. Mount using 304 SST hardware.
- 5. Spare Parts:
 - a. Two (2) membrane caps per chlorine sensor.
- 6. Product and Manufacturer:
 - a. Kuntze Krypton Multi water monitoring system.
 - b. No substitutions

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. Process liquid analytical analyzer/transmitters are to be set up, configured, and calibrated by Journeyman Instrumentation Technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION:

- A. Install primary analytical sensors and analyzer/transmitters in accordance with manufacturer's installation instructions. and standard installation details provided for this project.
 - 1. Refer to location diagrams and standard installation details provided for this project.

3.03 CALIBRATION:

- A. Provide printed calibration reports of the factory calibration and settings.
- B. Verify calibration check and output scaling in-situ and record all as-commissioned data including all smart device configuration parameters.
- C. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 76 00

PROCESS GAS ANALYTICAL MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide process gas analytical measurement instrumentation as specified in this section and in compliance with Section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and Testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
 - 1. Sustainable Design Submittals.
- B. Submit shop drawings for each specified instrument together with a completed Instrument Data Sheet in accordance with ISA S20 standard.
 - 1. Each instrumentation submittal shall include a copy of the respective specification section marked up to show compliance or non-compliance with specified requirements. Provide written justification for any non-compliance features.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.06 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 CHLORINE GAS LEAK DETECTORS

- A. Refer to Section 46 31 11.01 "Chlorine Gas Feed Equipment and Appurtenances".

2.02 AMBIENT OXYGEN MONITOR

- A. Refer to Section 46 31 53 "Ozone Generating and Feed Equipment".

2.03 AMBIENT AIR OZONE DETECTOR

- A. Refer to Section 46 31 53 "Ozone Generating and Feed Equipment".

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. Process gas analytical transmitters are to be set up, configured, and calibrated by Journeyman instrumentation technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION

- A. Install primary sensors and transmitters in accordance with manufacturer's installation instructions and in accordance with this specification.
 - 1. Refer to location diagrams and standard installation details provided for this project.

3.03 CALIBRATION

- A. Provide printed calibration reports of the factory calibration and settings.
- B. Verify calibration and output scaling in-situ and record all as-commissioned data including all smart device configuration parameters.
- C. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 78 00

PANEL MOUNTED INSTRUMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide panel mounted instruments and devices as specified in this section and in compliance with Section 40 70 00 and other related sections and Contract Documents.
- B. The Work of this section includes the provision of instrument data sheets for all instruments supplied for this project. The contractor shall provide an as-constructed instrument data sheet for each instrument supplied for this project based on the ISA S20 standard instrument specification forms.
- C. Refer to Section 40 61 13 for additional requirements related to instrument specification sheets.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. S5.1: P&IDs and Tagging.
 - 2. S5.4: Instrument Loop Diagrams.
 - 3. S7: Instrument Air.
 - 4. S12: Electrical Equipment for Hazardous Locations.
 - 5. S18.2: Alarm Management.
 - 6. S20: Instrument Specifications.
 - 7. S50: Electrical Control Signals.
 - 8. S75: Control Valve Design, Specification and Testing.
 - 9. S96: Valve Actuators
 - 10. S99: Control System Cyber Security.
 - 11. 101: Human-Machine Interfaces.

1.03 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.

- B. Submit shop drawings for each specified instrument together with a completed Instrument Data Sheet in accordance with ISA S20 standard.

- 1. Each instrumentation submittal shall include a copy of the respective specification section marked up to show compliance or non-compliance with specified requirements. Provide written justification for any non-compliance features.

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.
- B. Sustainability Standards Certifications.

1.06 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 INDICATORS AND METERS

- A. Features:
 - 1. LED display.
 - 2. 0.56 in. digit height minimum.
 - 3. 4-1/2 digit.
 - 4. Selectable decimal point.
 - 5. Scaled in engineering units.
- B. Input: 4 – 20 mAdc isolated.
- C. Signal Termination: Ungrounded.
- D. Input impedance: 10 ohms maximum.
- E. Accuracy: 0.1% of span.
- F. Power: 120 vac, $\pm 10\%$, 60 Hz.
- G. Construction: NEMA 4 unless indicated otherwise.

H. Mounting: Flush panel, 2.1-in. height, 4-in. wide, 6.75-in. depth.

I. Manufacturers

1. Siemens, RD200

2. Precision Digital

2.02 INDICATING LIGHTS

A. The quality and type of switches and pushbuttons shall be based on industrial grade types generally as described below.

B. All control indicator lamps in ordinary locations to be heavy duty oil tight such as Allen Bradley 800T or 800E or equivalent.

C. All control indicator lamps in classified or Category 1 & 2 areas, or outdoors to be heavy duty weatherproof such as Allen Bradley 800H or equivalent.

D. All control indicator lamps shall be LED push-to-test type.

2.03 SWITCHES AND PUSHBUTTON

A. The quality and type of switches and pushbuttons shall be based on industrial grade types generally as described below with contact rated for connected loads.

1. All control pushbutton switches, and selector switches in ordinary locations to be heavy duty oil tight such as Allen Bradley 800T or 800E.

2. All pushbutton switches, and selector switches in classified or Category 1 & 2 areas, or outdoors to be heavy duty weatherproof such as Allen Bradley 800H.

2.04 RELAYS

A. The quality and type of relays shall be based on industrial grade types generally as described below with contact rated for connected loads.

1. 120 VAC relays to be 4PDT, plug-in, complete with test button and operation indicator, and surge suppressor.

2. 24 VDC relays to be 2PDT plug-in, complete with test button and operation indicator, and surge suppressor diode.

3. Time delay relays for behind panel mounting to be Model 2PDT, plug-in, and programmable for sixteen (16) time ranges and four (4) operation modes.

4. Time delay relays for flush panel mounting and operator accessible timing range modifications to be SPDT, screw terminals, programmable for five (5) timing ranges

and eight (8) operation modes, complete with digital display, module for time settings and flexible protective cover.

5. Where the contact ratings of the relays listed are insufficient for the application select an appropriate type from an approved Manufacturer with the same quantity of contacts as was originally specified.
6. Provide relay plug-in sockets for DIN mounting complete with stacked screw clamp terminals.

2.05 ANALOG LOOP CURRENT ISOLATOR

A. The quality and type of analog loop current isolators shall be based on industrial grade types generally as described below.

1. Provide current loop signal isolators as required to provide isolation of milliampere transmission signals to prevent “ground loop” signal errors caused by mismatched transmitters and receivers.
2. Isolators are to be located in control panels and shall be Din rail mounted.
3. Analog loop current isolators shall be loop powered.
4. Isolator input and output signals to be 4-20 mA, with an error not exceeding 0.1 percent of span. Input resistance will not exceed 550 ohms with an output load of 250 ohms.

B. Manufacturers

1. Moore Industries
2. Phoenix Contact

2.06 INTRINSIC SAFETY BARRIERS AND RELAYS

A. The quality and type of analog loop current isolators shall be based on industrial grade types generally as described below.

1. Provide intrinsic safety barriers where required for two-wire transmitters of the active, isolating, loop powered type.

a. Manufacturers:

- (1) MTL
- (2) Phoenix
- (3) Stahl

- (4) P+F
- 2. Provide dual type intrinsic safety barriers for process switches.
 - a. Manufacturers:
 - (1) MTL
 - (2) Phoenix
 - (3) Stahl
 - (4) P+F
- 3. Intrinsic safety relays.
 - a. Manufacturers:
 - (1) MTL
 - (2) Phoenix
 - (3) Stahl
 - (4) P+F

2.07 SURGE SUPPRESSORS

- A. Provide on instrumentation and control signals whose source or destination is outside any building or structure.
- B. Provide on phone lines and copper data network connections located outside building.
- C. Provide on 120 vac power feeds.
- D. For 120 VAC and 24 VDC power circuits
 - 1. Phoenix Contact PLT-SEC-T3-120-FM or approved equal
- E. For analog circuits:
 - 1. Phoenix Contact TT-2PE-24DC or approved equal

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. Panel mounted instruments and related operator devices are to be set up, configured, and calibrated by Journeyman instrumentation technician working under the approval of the instrument manufacturer.

3.02 INSTALLATION

- A. Install panel mounted instruments and related operator devices in accordance with manufacturer's installation instructions and in accordance with this specification.
- B. Review the process area classification and panel environmental ratings and install instruments and operator devices with environmental and hazardous area ratings equal to or better than the area requirements.
- C. Use normally closed contacts for alarm actuation. The contacts open to initiate the alarm.
- D. Use normally open contacts to control equipment. The contacts close to start the equipment.
- E. Contacts monitored by solid state equipment to be hermetically sealed and adequately rated for the connected load.
- F. Contacts monitored by electro-magnetic devices such as mechanical relays to be rated NEMA ICS 2, designation B300.
- G. Provide double barriers between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
- H. Switch electrical enclosures to be rated EEMAC 4, minimum.
- I. 120 VAC switches to have a 4 A rating.

3.03 CALIBRATION

- A. Provide printed calibration reports of the factory calibration and settings.
- B. Verify calibration and output scaling in-situ and record all as-commissioned data including all smart device configuration parameters.
- C. Submit calibration reports for review by the Engineer and include copies of reviewed and accepted calibration reports in the O&M manuals.

3.04 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 40 99 90

PACKAGE CONTROL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide a complete operating control system including the design, documentation, supply, delivery, installation, tuning, testing, commissioning, and warranty.
- B. Assemble panels and install panel instruments and wiring in equipment manufacturer's factory.
- C. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

1.02 SUBMITTALS

- A. Submit the following shop drawings in accordance with Section 01 33 00.
- B. Shop drawings shall include:
 - 1. Bill of materials
 - 2. Network interface drawings
 - 3. Electrical schematic and wiring diagrams
 - 4. Cause and Effect Diagram or Shutdown Key
 - 5. Electrical ladder diagrams
 - 6. Interconnection diagrams
 - 7. External Interface diagrams
 - 8. Control Panel Arrangement Drawings
 - 9. I/O Lists
 - 10. MODBUS TCP/IP Address List, if applicable
 - 11. ISA Style Instrument Datasheets
 - 12. Instrument Alarm, Range and Setpoint List

13. Configuration/parameter sheets including switch settings, parameter settings, and addresses. Show factory default settings and proposed settings
14. Diagram showing dip switches complete with proposed settings.
15. Control Narrative covering all logic and sequences of operation
16. PLC program documentation

C. Operation and Maintenance Data:

1. Operation and maintenance manuals shall be specific to equipment purchased and crossing out of non-applicable items is not acceptable.
2. Comply with requirements of Section 01 78 23.

1.03 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.
- B. Provide spare parts that are identical to and interchangeable with similar parts installed.
 1. Selector Switch, Pushbutton, and Pilot Light: one of each type used.
 2. Light Bulb: one of each type used.
 3. Fuse: two of each type and rating used.
 4. Surge Suppressors: one of each type used.
- C. Provide a list of recommended spare parts for the first year of operation and for the first five years of operation, including a price list and location of the nearest facility from which all spare parts can be obtained.

1.04 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.

1.05 DELIVERY STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10.

1.06 WARRANTY

- A. As specified in Section 01 78 36.

PART 2 - PRODUCTS

2.01 CONTROL PANELS

- A. Refer to Section 26 27 17 and Section 40 67 00 “Control System Equipment Panels and Racks”.

2.02 CONTROL PANEL COMPONENTS

- A. Refer to Section 40 78 00, Section 40 66 00, and Section 40 67 00 “Control System Equipment Panels and Racks”.
- B. The following pilot device colors shall be used:
 - 1. Running Status Light: Red
 - 2. Stopped Status Light: Green
 - 3. Position Open Status Light: Red
 - 4. Position Closed Status Light: Green
 - 5. Alarm Status Light – Major or Safety: Red
 - 6. Warning or Minor Alarm Status Light: Amber
 - 7. Ready Status Light: Blue
 - 8. Operating Mode – Normal Mode: Blue
 - 9. Operating Mode – Alternate Mode: Amber
 - 10. Start Pushbutton: Black
 - 11. Stop Pushbutton: Black
 - 12. Test Pushbutton: Black
 - 13. Reset Pushbutton: Black
 - 14. E-Stop Pushbutton: Red push-pull with mushroom
 - 15. Overload Reset Pushbutton: Blue with White “R”
 - 16. Selector Switch: Black with White Insert
 - 17. Legend Plate: Black with White Lettering

- C. Where a PLC or similar logic controller is used, provide an Ethernet/IP communication module for connection to the Plant SCADA System.
- D. As a minimum, data exchange shall include:
 - 1. Equipment status (running, off, local/remote mode, PLC AUTO/PLC MANUAL mode).
 - 2. Alarm/Fail condition of machine.
 - 3. Operating modes.
 - 4. Operating status values; discrete and analog.
 - 5. All other data points required for the safe and reliable operation of the equipment.
- E. Develop a data exchange table/map. Data table shall include:
 - 1. For each data point, its name, register location, and tag number.
 - 2. Group data by type; e.g., discrete inputs, discrete outputs, analog inputs, analog outputs.
- F. Programmable Logic Controller
 - 1. Preferred PLC equipment is based on Rockwell Automation Allen-Bradley ControlLogix family of products, and shall be programmed with RSLogix 5000 software, latest revision.
 - a. Refer to Section 26 27 17 “Control Panels” for Allen-Bradley components.
 - 2. Each new PLC panel assembly is to include a constant voltage regulating transformer suitably sized for the panel load equal to Sola Hevi-Duty MCR series and incoming power transient surge suppression equal to Sola Hevi-Duty STV100K series. Connect the surge suppressor dry contacts to a PLC input at each panel and notify the control system integrator/programmer.
- G. OIT Equipment:
 - 1. Provide a Rockwell Automation PanelView Plus color touchscreen OIT unit flush mounted in the control panel.
 - 2. The display shall be 14 inch TFT LCD.
 - 3. 24 VDC power supply with internal battery backup.
 - 4. NEMA 4X environmental protection with hazardous area rating if required.
 - 5. Program the HMI unit with latest version of HMI programming software.

6. The HMI shall be programmed to provide for the monitoring and control of all input and output points, loops and systems through graphic display screens. Additionally, the HMI programming shall include:
 - a. Process parameter displays.
 - b. Alarm management.
 - c. Trending of key process variables.
 - H. For all PLCs provided, provide all program files for end user modification and programs shall not be proprietary or require vendor for accessibility.
 - I. Provide all run-time licenses necessary for the operation of the new PLC and HMI installations.
 - J. Network Cabling:
 1. Provide interconnection cabling of all Ethernet devices internal to the panel. Provide CAT6A shielded patch cables: factory made, ruggedized with a protective connector boot.
 2. Interconnectivity cabling for the Ethernet network external to the panel will be provided by the installing Contractor.
- 2.03 INSTRUMENTATION
- A. Instrumentation supplied as part of a pre-manufactured system shall be the manufacturer's standard equipment. Instruments shall be industrial grade and suitable for the conditions in which they will be installed.
 - B. Instrumentation shipped loose shall meet the requirements of the following sections:
 1. Flow devices: Section 40 71 00.
 2. Level devices: Section 40 72 00.
 3. Pressure, strain, and force devices: Section 40 73 00.
 4. Temperature devices: Section 40 74 00.
 5. Process liquid analytical devices: Section 40 75 00.
 6. Process gas analytical devices: Section 40 76 00.
 - C. All instrumentation shipped loose shall be industrial grade and suitable for the conditions in which they will be installed.

2.04 EQUIPMENT IDENTIFICATION

A. Identify electrical and automation equipment with nameplates.

1. Refer to Section 26 05 53 for requirements, wording on nameplates to be approved by Engineer prior to manufacture.
2. All instrumentation and panel nameplates shall include the prefix P25-.

2.05 PROGRAMMING TOOLS AND ACCESSORIES

A. Provide the following as minimum:

1. Programming tools for each different type of programmable equipment:
 - a. Software program complete with interconnecting cable, signal converter, instruction manual and equipment documentation; or
 - b. Programming keypad and accessories.
2. Backup Copies of Application Software:
 - a. One copy for each unique version of software program or data.
 - b. Machine-readable backup software copy in the form of USB Memory Stick.

PART 3 - EXECUTION

3.01 SIGNAL CHARACTERISTICS

A. Analog Signals:

1. 4 to 20 mA dc, in accordance with compatibility requirements of ISA S50.1.
2. Unless otherwise specified or shown, use Type 2, two-wire circuits.
3. Transmitters: Load resistance capability conforming to Class L.
4. Fully isolate input and output signals of transmitters and receivers.

B. Discrete Output Signals (from vendor panel perspective):

1. Two-state logic signals.
2. Provide voltage free contacts for 24V DC signals to the local plant PLC. Minimum switching current to be lower than the PLC input current consumption. Provide interposing relays to isolate discrete outputs from field wiring.

3. Normal status signals shall be normally open, close to activate isolated contacts.
 4. Fault signals shall be normally closed, open to activate isolated contacts.
- C. Discrete Input Signals (from vendor panel perspective):
1. Two-state logic signals.
 2. Provide interface for 24V DC wet signals from the PCS.

3.02 ELECTRICAL POWER AND SIGNAL WIRING

- A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.
- B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.
- C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.
- D. Do not splice or tap wiring except at device terminals or terminal blocks.
- E. All wires and cables inside the control panels shall be identified on both ends.
- F. Route power cabling separate and spaced out (so that there is no derating factors applied to the cabling). Cable shall be routed to allow for maintenance of systems, and shall not impede access in the room or present obstructions.

3.03 STARTUP AND TESTING

- A. Comply with the requirements specified in Section 01 78 25.
- B. See system specification for startup and testing requirements.

3.04 FIELD TESTING

- A. Instruments and circuits shall be field testing and calibrated prior to commissioning.

3.05 TRAINING

- A. Comply with the requirements specified in Section 01 78 25.
- B. See system specification for startup and testing requirements.

3.06 CONTRACT CLOSEOUT

- A. Provide in accordance with Section 01 70 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 41 22 13.13

BRIDGE CRANES AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test bridge cranes, hoists, motors, gear reducers, controls and appurtenances as indicated and in compliance with Contract Documents.
 - 1. Rail and supporting beams included in building structure, refer to structural drawings.
 - 2. Hoist capacities and operating data are indicated in the Bridge Crane Schedule.

1.02 REFERENCES:

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9: Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11: Load Ratings and Fatigue Life for Roller Bearings.
- D. American Society of Mechanical Engineers (ASME):
 - 1. B30.16: Overhead Hoists (Underhung) Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings.
 - 2. B30.17: Overhead and Gantry Cranes (Top Running, Single Grinder, Underhung Hoist).
 - 3.
- E. American Welding Society (AWS):
 - 1. D1.1: Structural Welding Code Aluminum.
- F. National Electric Code (NEC).
- G. National Electrical Manufacturers Association (NEMA):
 - 1. MG1: Motors and Generators.
- H. Occupational Safety and Hazard Association (OSHA):
 - 1. 29 CFR 1910.179: Overhead and Gantry Cranes.

- I. Crane Manufacturers Association of America (CMAA):
 - 1. 70-2004: Specification for Top Running Bridge 7 Gantry Type Multiple Girder Electric Overhead Traveling Cranes.
 - 2. 74-2004: Specification for Top Running & Under Running single Girder Electric Traveling Cranes Utilizing Under Running trolley Hoist.
- J. International Building Code (IBC):
 - 1. 2018 IBC

1.03 SUBMITTALS:

- A. Comply with requirements specified in Section 01 33 00. Data regarding bridge crane characteristics and performance.
 - 15. Certified setting plans, with tolerances, for anchor bolts.
 - 16. Manufacturer's literature as needed to supplement certified data.
 - 17. Operating and maintenance instructions and parts lists.
 - 18. Listing of reference installations as specified with contact names and telephone numbers.
 - 19. List of recommended spare parts other than those specified.
 - 20. Shop and field inspection reports.
 - 21. Motor shop test results.
 - 22. Qualifications of field service engineer.
 - 23. Recommendations for short and long-term storage.
 - 24. Shop and field testing procedures, equipment to be used.
 - 25. Special tools.
 - 26. Number of service person-days provided and per diem field service rate.
 - 27. Manufacturer's product data, specifications and color charts for shop painting.
 - 28. The latest ISO 9001 series certification.
 - 29. Provide Certificate of Responsibility. See Section 01 33 00 for Certificate form.

30. Provide sealed drawing height and weight of equipment serviced by the hoisting equipment including hook height and travel dimensions.
31. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and designed for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
 - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated.
- D. A copy of the contract mechanical process, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required" or provide a statement that no changes are required.
 1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
- E. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.
- 1.04 SPARE PARTS:
 - A. Comply with the requirements specified in Section 01 61 00.
 - B. Provide spare parts that are identical to and interchangeable with similar parts installed.

1.07 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Overhead bridge cranes to be in conformance with CMAA Specification No. 74 and as specified and indicated.
- C. Permanently mark the capacity of the hoist and trolley on each hoist and crane, in easy to read letters and in a prominent position.
- D. Provide only safety type hooks.
- E. Provide hoists so that hook can reach the floor at the lowest level of the lift.
- F. Do not use bridge crane for construction purposes of any nature.
- G. Cranes shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.
- H. Welding: In accordance with American Welding Society Code D1.1.
- I. Provide shop tests as specified.
- J. Crane manufacturer shall provide beams, hoists, motors, gear reducers, switches, and controls regardless of manufacturer as a complete integrated package to ensure coordination, compatibility and operation of the systems.
- K. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.
- L. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 - 2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping and electrical:
 - a. 1 person-days.
 - 3. Functional Testing: Calibrate, check alignment and perform a functional test. Tests to include all items specified.
 - a. 1 person-days.
 - 4. Performance Testing: Field performance test equipment specified.

- a. 1 person-days.
 - 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.
 - a. 1 person-days.
 - 6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 - 7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
 - M. Crane manufacturer shall have a minimum of five (5) operating installations with cranes of the size specified and in the same service as specified operating for not less than five (5) years.
- 1.08 DELIVERY, STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- A. Crane capacities and operating data are indicated in the Bridge Crane Schedule.

2.02 CRANE MANUFACTURERS:

- A. American Crane & Equipment.
- B. Konecranes
- C. Iron Mountain Crane & Hoist.

2.03 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. The Contractor shall conform to the seismic design requirements for this project and for the work of this specification section.
- C. Provide all equipment bases, anchorage, supports and foundations designed in accordance with the seismic requirements indicated and specified.

- D. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were performed and that all components have been sized for the seismic forces specified and indicated.

2.04 BRIDGE:

- A. Top running or under running type crane bridge as indicated in the Bridge Crane Schedule.
 - 1. Provide top running cranes designed to resist all vertical, lateral and torsional forces combined as specified in CMAA-70 and 74.
 - 2. Provide under running cranes in accordance with CMAA-74.
- C. Provide girders connected with end trucks.
- D. Provide connections in both vertical and horizontal planes to keep entire bridge structure square and aligned under conditions specified and indicated and during shipping and installation.
- E. Bridge and truck: Welded steel construction. Provide rigid structure and trucks attached to bridge girders with turned bolts.
- F. Provide bridge with holes drilled and reamed for matched fit before final assembly and welding.
- G. End trucks: minimum wheel base 1/8 of crane span.
 - 1. Provide bridge trucks with ball or roller bearings and medium or high carbon steel or high strength alloy steel fixed or rotating type steel axles.
 - 2. Provide trucks to prevent drop in excess of 1-inch in the event of wheel or axle failure.
 - 3. Provide entire truck machine as a factory assembled unit to provide perfect alignment.
- H. Truck Wheels: double flanged rolled bridge type forged or cast steel with hardened treads.
 - 1. Wheels to carry maximum wheel load under normal operating conditions. Diameter not less than that shown for maximum load in CMMA-74.
- I. Provide driving mechanism such that travel will be steady and free from vibration or racking in any part of structure while traveling under maximum load at all speeds. Prevent any tendency for crane structure to get out of line while traveling along runway under any operating condition.

2.05 ELECTRIC HOISTS:

- A. Electric Hoists: Spur-gear driven antifriction bearings throughout. Provide a load side holding hoist motor brake and a separate electrically operated non-load brake. Design brake with capability of supporting the full load at any point when the motor is stopped. Holding brake shall be externally adjustable, electrically operated friction disk brake that shall apply automatically when the power is off. The brake shall hold 150 percent of the rated load and 125 percent of the rated load at any operating speed. Design shafts of motor, drum, and drum pinion to run in grease-lubricated ball or roller bearings. Design the and gear train and bearings to be oil-bath lubricated.
- B. Provide hoist with right angle mounting with H-wheel trolley, motorized as specified and indicated.
- C. Hoist: Standard type.
- D. Design drum with machine-cut grooves and guarded flanges and with capacity to take entire run of cable in one layer with no overlapping.
- E. Provide hoist with an upper and lower geared limit switch with automatic reset control circuit to prevent overtravel. Settings to be field adjustable in accordance with OSHA 29 CFR 1910.179.
- F. Supply sufficient hoisting cable with hoists for two-part single and to accommodate not only the maximum lift but two additional wraps on drum. Make cable flexible high-strength plowsteel cable with a load safety factor of at least 5 to 1.
- G. Make load block of rugged construction containing a ball-bearing sheave and a high-grade forged-steel swivel hook with antifriction bearings.
- H. Provide control equipment in an enclosed compartment which forms an integral part of hoist and include a transformer for a 120-volt control circuit.

2.06 TROLLEYS:

- A. Plain Trolleys: Push type with a hole for attaching suspension hook.
- B. Army Type Hoists: Close headroom type, integrally built into a 4-wheel plain or geared trolley.
- C. Provide trolley operating wheels with chain guides, and make chains for each of sufficient length to hang 3 feet above operating floor.
- D. Motor-Driven Trolleys: Four-wheel type consisting of a fully enclosed electric motor equipped with a magnetic brake, a geared transmission completely enclosed in an oiltight housing and suspended on flanged driving wheels with power to two wheels. Use ball or roller bearings throughout.

- F. Make trolleys designed for operation on beam or rail indicated on drawings. Trolleys to be provided by the hoist manufacturer.

2.07 SAFETY STOPS:

- A. Provide safety stops on all open ends of track (or where indicated) to prevent trolley from running off ends or damaging building or striking process piping. Provide stops with capability of withstanding impact imposed by motion of fully loaded hoist and trolley.

2.08 TRACK:

- C. Monorail Track: Standard beam of sizes indicated on drawings.
- D. Shop fabricate all curves for either track or switches to radius indicated.
- E. Erect track level throughout, with section ends machined fitted and spliced with web-type or other designed couplings to provide flush level connections. Maximum gap between adjacent ends not exceeding 1/16-inch.

2.09 CABLE REELS:

- A. Manufacturers:
 - 1. Gleason Reel Div.
 - 2. Aero-Motive Mfg. Co.
 - 3. Liftech. Feed cable reel for electric current supply for all electric hoists with trolleys, except as otherwise indicated, through a single flexible, multi-conductor power cable from a self-winding spring-operated reel located near mid-point of trolley travel or where indicated on drawings.
- C. Furnish junction box to connect cable reel to power supply circuit with hoist.

2.10 ELECTRICAL CONTROLS:

- A. Supply complete integral electrical control system with the electric hoisting equipment (by hoist manufacturer) consisting of starters, circuit breakers, overload relays, limit switches, control transformer for a 120-volt control circuit, control relays, and controlling devices.
- B. Furnish magnetic controls for motors. Design controls to permit "inching" in both forward and reverse directions under full load, automatically regulated acceleration, and rapid brake response.
- C. Provide each hoist with limit switches of automatic-reset control circuit type to prevent overtravel in both raising and lowering directions.

- D. Compliance: Make all electrical equipment including motors, controls, resistors, brakes plus all conduit, wiring, panels, and enclosures with applicable requirements for materials, workmanship, construction, and installation of latest NEMA and National Electrical Code Standards.

2.12 MOTORS:

- A. Provide in accordance with Section 26 20 00 and as specified herein.
- B. Motors for Hoists and Trolley: Totally enclosed, reversible, induction motors especially adapted to hoist service.
 - 1. Enclosure: NEMA 4X.
 - 2. Insulation: Minimum Class "F" with Class "B" temperature rise, 40 degrees C ambient unless otherwise indicated or specified.
 - 3. Service Factor: 1.15.
 - 4. Provide capacity to start and operate hoists at maximum speed rated capacity indicated without exceeding nameplate ratings for current and power and without operating in the service factor.
 - 5. Provide ball or roller bearings, in accordance with ABMA Standard 9 and Standard 11; minimum L-10 life of 100,000 hours.
 - 6. Premium efficient motors, nominal and minimum motor efficiencies per NEMA MG1.
 - 7. Rating: 460V, 3-phase, 60 Hertz.

2.13 PUSHBUTTON CONTROL:

- A. Provide pendent pushbutton control station with sufficient pushbuttons to control all operations of hoists and trolley. Clearly mark each pushbutton to indicate its function. Make cable long enough to reach within 4 feet (1.2 meter) of operating floor or platform level with a supporting chain. If necessary, attach an arm to hoist so that pendent cable and pushbutton controls will hang vertically and be readily accessible from operating positions.

2.14 CONDUCTORS AND COLLECTORS:

- A. Manufacturers:
 - 1. Insul-8-Bar Protected Conductors made by Insul-8-Corp.
 - 2. Safety-T-Bar Conductor Systems made by Howell Corp.

3. Duct-O-Bar Conductor System made by Duct-O-Wire Co. Use equipment and accessories approved by Underwriter's Laboratories (UL).

- C. For conductor for electric current supply provide safety type in which conductor is shielded by a molded-plastic cover that surrounds conductor except for a slotted opening shaped to contour of collector head. Provide separate conductor for each phase. (Dual conductors in a single insulating shield are not acceptable.) Make conductor of plated steel or copper designed for carrying maximum anticipated current. Make molded-plastic shield of high dielectric strength, rigid yet sufficiently flexible to permit bending to radius of curves or switches, and resistant to corrosion and deterioration from sunlight or weather. Space insulated supports not over 5 feet on straight track and 3 feet on curves.
- D. Provide weather shield for exterior conductors.
- E. Provide collectors of sliding shoe type with an adjustable spring-load arm capable of horizontal or vertical movement to automatically adapt to irregularities of conductor. Set shoe in a molded-plastic head that will prevent external contact with shoe when it is running on conductor. There shall be no exposed bare current-carrying surfaces or wires in collector or arm where shoe is in contact with conductor.

2.17 SHOP PAINTING:

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09 96 00.
- B. Surface preparation, mixing and application and safety requirements shall be in accordance with the paint manufacturer's printed instructions and as specified.
- C. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- D. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install items in accordance with manufacturer's printed instructions and as indicated and specified.
- B. Check horizontal and vertical alignment of track and rails.
- C. Erect rack level throughout, with section ends machined fitted and spliced with web-type couplings to provide flush level connections. Maximum gap between adjacent ends not exceeding 1/16-inch.

- D. Do not use cast fittings.

3.02 FIELD TESTING:

- A. Provide as specified herein. Perform all tests with instrumentation controls and motor controls. Perform testing in accordance with OSHA 29 CFR 1910.179 and as specified herein.
- B. After installation of hoist equipment, and after inspection, operation, testing and adjustment have been completed by manufacturer's field service technician, conduct test for each hoist in presence of the Engineer to determine its ability to operate at rated speeds and capacity under conditions specified and indicated. During tests, observe and record, capacity and motor inputs. Promptly correct or replace all equipment not conforming to the requirements of this section revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results are obtained. Contractor to provide all labor, weights and materials for conducting tests.
 - 1. Provide a 60 minute test for each hoist.
 - 2. Running test shall consist of moving hoist and trolley through two complete cycles. The first cycle will be with no load. For the second cycle, the unit will be loaded with 100 percent of the specified load rating.
 - 3. Test and simulate all limit switches, locking and safety devices.
- C. Make all adjustments to place equipment in specified working order at time of above tests.
- D. After three (3) unsuccessful testing attempts, remove and replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated.

3.03 FIELD TOUCH-UP PAINTING:

- A. After installation and testing, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 41 22 23.19
HOISTING EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test hoisting equipment, motors, gear reducers, controls and appurtenances as indicated and in compliance with Contract Documents.
 - 1. Rail and supporting beams included in building structure, refer to structural drawings.
 - 2. Hoist capacities and operating data are indicated in the Hoisting Schedule in Paragraph 3.06.

1.02 REFERENCES:

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9: Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11: Load Ratings and Fatigue Life for Roller Bearings.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B30.16: Overhead Hoists (Underhung) Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings
- C. American Welding Society (AWS):
 - 1. D1.1: Structural Welding Code - Steel.
 - 2. D1.2: Structural Welding Code - Aluminum.
- D. National Electric Code (NEC), NFPA 70.
- E. National Electrical Manufacturers Association (NEMA):
 - 1. MG1: American National Standard for Motors and Generators.
- F. Occupational Safety and Hazard Association (OSHA):
 - 1. 29 CFR 1910.179: Overhead and Gantry Cranes.
- G.

1.

H. International Building Code (IBC):

1. 2021 IBC

1.03 SUBMITTALS:

2. Data regarding hoisting equipment characteristics and performance:
4. Certified setting plans, with tolerances, for anchor bolts.
5. Manufacturer's literature as needed to supplement certified data.
6. Operating and maintenance instructions and parts lists.
7. Listing of reference installations as specified with contact names and telephone numbers.
8. List of recommended spare parts other than those specified.
9. Shop and field inspection reports.
10. Motor shop test results.
11. Qualifications of field service engineer.
12. Recommendations for short and long-term storage.
13. Shop and field testing procedures, equipment to be used.
14. Special tools.
15. Number of service person-days provided and per diem field service rate.
16. Manufacturer's product data, specifications and color charts for shop painting.
17. The latest ISO 9001 series certification.
18. Provide Certificate of Responsibility. See Section 01 33 00 for Certificate form.
19. Provide scaled drawing height and weight of equipment serviced by the hoisting equipment including hook height and travel dimensions.
20. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and designed for the service conditions specified and indicated. If materials other than those specified

are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.

- b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and designed for the service conditions specified and indicated.
 - E. A copy of the contract mechanical process, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with “No changes required” or provide a statement that no changes are required.
 - 1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
 - F. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - 1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.
- 1.04 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
 - B. Provide spare parts that are identical to and interchangeable with similar parts installed.
- 1.06 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Permanently mark the capacity of the hoist and trolley on each hoist, in easy to read letters and in a prominent position.

- C. Provide only safety type hooks.
- D. Provide hoists so that hook can reach the floor at the lowest level of the lift.
- E. Do not use hoists for construction purposes of any nature.
- F. Hoists shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.
- G. Welding: In accordance with American Welding Society Code D1.1.
- H. Provide shop tests as specified.
- I. Hoisting equipment manufacturer shall provide hoists, motors, gear reducers, switches, and controls regardless of manufacturer as a complete integrated package to ensure coordination, compatibility and operation of the systems.
- J. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.
- K. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 - 2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping and electrical:
 - a. 1.0 person-day.
 - 3. Functional Testing: Calibrate, check alignment and perform a functional test. Tests to include all items specified.
 - a. 1.0 person-day.
 - 4. Field Testing: Field performance test equipment specified.
 - a. 1.0 person-day.
 - 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.
 - a. 1.0 person-day.

- 6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 - 7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
 - L. Manufacturer of hoisting equipment shall have a minimum of five (5) operating installations with hoists of the size specified and in the same service as specified operating for not less than five (5) years.
- 1.07 DELIVERY, STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- A. Hoisting equipment capacities and operating data are indicated in the Hoist Schedule.

2.02 HOIST AND TROLLEY MANUFACTURERS:

- A. Dresser Industries.
- B. ACCO-Wright.
- C. Columbus McKinnon Corporation.
 - 1. Yale Hoisting Equipment Division.
 - 2. Shaw Box.

2.03 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. The Contractor shall conform to the seismic design requirements for this project and for the work of this specification section.
- C. Provide all equipment bases, anchorage, supports and foundations designed in accordance with the seismic requirements indicated and specified.
- D. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were

performed and that all components have been sized for the seismic forces specified and indicated.

2.04 ELECTRIC HOISTS:

- A. Electric Hoists: Spur-gear driven antifriction bearings throughout, a mechanical load brake, and a separate electrically operated motor brake. Design mechanical load brake with capability of supporting the full load at any point when the motor is stopped. Motor brake shall be externally adjustable, electrically operated friction disk brake that shall apply automatically when the power is off. The brake shall hold 150 percent of the rated load and 125 percent of the rated load at any operating speed. Design shafts of motor, drum, and drum pinion to run in grease-lubricated ball or roller bearings. Design the mechanical-load brake and gear train and bearings to be oil-bath lubricated. Helical-gear driven hoists may also be accepted.
- B. Arrange hoist for parallel lug mounting from a 4-wheel geared trolley.
- C. Hoist: Standard type.
- D. Design drum with machine-cut grooves and guarded flanges and with capacity to take entire run of cable in one layer with no overlapping.
- E. Provide hoist with an upper and lower geared limit switch with automatic reset control circuit to prevent overtravel. Settings to be field adjustable in accordance with OSHA 29 CFR 1910.179.
- F. Supply sufficient hoisting cable with hoists for two-part single reeving and to accommodate not only the maximum lift but two additional wraps on drum. Make cable flexible high-strength plowsteel cable with a load safety factor of at least 5 to 1.
- G. Make load block of rugged construction containing a ball-bearing sheave and a high-grade forged-steel swivel hook with antifriction bearings.
- H. Provide control equipment in an enclosed compartment which forms an integral part of hoist and include a transformer for a 120-volt control circuit.

2.05 MANUAL HOISTS:

- A. Manual hoists shall be trolley supported, fully enclosed high-speed, spur-gear, ball or roller bearing, hand-operated, chain type conforming to ASME HST-2. Hoist shall be supplied with a clutch designed to limit the chain pull to not more than 150 percent of that required to lift the rated load capacity of the hoist. Hoist shall have a Weston-type automatic brake for positive load control.
- B. Provide with chain guides with chain of sufficient length to hang 3-ft above operating level and a chain bucket to collect the load chain and arranged not to interfere with the smooth operation of the hoist. Hoist shall be provided with a clevis connection or suspension hook to connect to the trolley.

- C. The hoisting machinery shall consist of a chain sprocket, driven through suitable gear reductions by a chainwheel operator, respectively, load blocks, hooks, chain, sheaves, and hoist braking. The chain sprocket and its surrounding members shall be constructed so as to minimize abrasion, crushing or jamming of the hoist chain. Chain hoists shall have chain storage adequate for storing the full lift of chain and shall be designed and located to avoid chain interference while hoisting.
- D. Hoist shall have automatic overload protection via load limiter.

2.06 TROLLEYS:

- A. Provide trolley operating wheels with chain guides and make chains for each of sufficient length to hang 3 feet above operating floor.
- B. Make trolleys designed for operation on beam or rail indicated on drawings. Trolleys to be provided by the hoist manufacturer.
- C. Motor-Driven Trolleys: Four-wheel type consisting of a fully enclosed electric motor equipped with a magnetic brake, a geared transmission completely enclosed in an oiltight housing and suspended on flanged driving wheels with power to two wheels. Use ball or roller bearings throughout.
- E. Manual Trolleys: Shall be designed for the Service Class 1 where the trolley operates a maximum of 12.5 percent of working hours with loads frequently approaching rated load.
 - 1. Wheel axles shall be made of alloy steel, accurately machined and ground to receive inner bearing races. Provisions shall be made to prevent a drop of more than 1 inch in case of axle failure.
 - 2. Trolleys shall be chain-driven trolleys via a chain sprocket linked to a trolley drive wheel that engages the monorail track. The chain sprocket shall be designed to accept the chain and shall attach to the trolley in such a manner that the driving chain does not interfere with normal hoist operation. The driving chain loop height shall be between 4 and 5 feet above the operating floor level.
 - 3. Wheels shall be forged steel with treads and flanges heat treated. All clearances, wheel loads, and manufacturing tolerances shall be in accordance with MMA MH27.1. Wheels on manual trolleys shall be geared and designed to operate on the standard monorail track as shown on the Drawings.
 - 4. Bearings shall be combination radial and thrust type, double-row, angular contact special ball bearings, either prelubricated and sealed, or fitted for pressure lubrication. They shall be prelubricated and sealed and have a minimum B10 bearing life of 3,000 hours. All pressure lubrication fittings shall be located in accessible locations for ease of maintenance.

2.07 SWITCHES AND SWING-OUT SECTIONS:

A. Manufacturers:

1. American Monorail Co.
2. Richards-Wilcox Mfg.
3. ACCO-Louden.Switches: Glide or sliding type, manually operated. Design transfer mechanisms and locking devices capable of positioning switch to maintain true vertical and horizontal alignment of track and conductors and prevent switch operation when any part of trolley is in switch.

C. Furnish swing-out sections at roll-up doors as indicated on drawings.

2.08 SAFETY STOPS:

- A. Provide safety stops on all open ends of track (or where indicated) to prevent trolley from running off ends or damaging building. Provide stops with capability of withstanding impact imposed by motion of fully loaded hoist and trolley.
- B. Provide hoist equipped with smart feature controls. The intelligent control should include sway control, snag prevention, adaptive speed control, and definable protected areas. The defined protected areas much create a virtual wall where the crane in not allowed to enter.

2.09 TRACK:

- A. Monorail Track: Standard beam of sizes indicated on drawings.
- B. Shop fabricate all curves for either track or switches to radius indicated.
- C. Erect track level throughout, with section ends machined fitted and spliced with web-type or other designed couplings to provide flush level connections. Maximum gap between adjacent ends not exceeding 1/16-inch.

2.10 CHLORINE CYLINDER GRAB:

A. Models and Manufacturers:

1. American Chain & Cable Co.
2. Bushman Equipment Co.
3. B.E. Wallace Products Corp.Chlorine Cylinder Grab: Make suitable for handling standard 1-ton containers weighing 3,500 lb. when full.

C. Make cylinder grab of structural channels at least 5-inch deep and about 80 inch long welded back-to-back but held apart sufficiently to mount heavy swing hooks between

them at each end. Make hooks of heavy steel plate or bars shaped to contour ends of chlorine cylinders to swing freely on steel hinge bolts or pins firmly secured to both channels near each end.

- D. Locate lifting eye centrally lengthwise of channels.
- E. Total height from the top of the hole in lifting eye to inside of hook in lift position on cylinder not to exceed 13-inch.

2.11 PALLET LIFTER:

- A. Manufacturers:
 - 1. Cady Metal Fabrication, Inc.
 - 2. Lewis-Shepard Co., a subsidiary of Hyster Co.
 - 3. Heppenstall Co., Material Handling Div. Pallet Lifter: C-shaped welded box frame with two heavy alloy-steel forks, a lifting eye, a counterweight, and guiding handles.
- C. Design pallet lifter with a lifting capacity as indicated at least 48 inch and be no wider than 25 inch.

2.12 PORTABLE GANTRY:

- A. Manufacturers:
 - 1. Spanco, Inc.
 - 2. Konecranes
- B. Portable Gantry: Four-leg rolling-type gantry with capacity as indicated. Horizontal standard aluminum beam suspended at each end by pipe legs adjustable for both height and span at floor, adequately braced, with locking swivel casters for each leg.
- C. Position legs and span by pins provided with springs and a locking device to fit matching holes in telescoping pipe members.
- D. Fit casters with ball bearings and wheels of rubber plastic treads designed for rated capacity of gantry.
- E. Provide stops at ends of beam to prevent trolley rolloff.
- F. Design Factors: Gentries shall be designed for a factor of
 - 1. 15 percent of the rated capacity for hoist and trolley weight, and
 - 2. 25 percent of the rated capacity.

2.13 CABLE REELS:

A. Manufacturers:

1. Gleason Reel Div.
2. Aero-Motive Mfg. Co.
3. Liftech. Feed cable reel for electric current supply for all electric hoists with trolleys, except as otherwise indicated, through a single flexible, multi-conductor power cable from a self-winding spring-operated reel located near mid-point of trolley travel or where indicated on drawings.
 1. The cable shall have at least four conductors.
 2. The reel shall have a swivel base.
 3. The reel shall have an explosion-proof Class 1, Division 1 or 2, Group C/D enclosure based on the rating of the space where the equipment is located.
 4. The reel shall have a weatherproof enclosure when located outdoors.

C. Furnish junction box to connect cable reel to power supply circuit with hoist.

2.14 ELECTRICAL CONTROLS:

- A. Provide in accordance with Division 40 and as specified herein.
- B. Supply complete integral electrical control system with the electric hoisting equipment (by hoist manufacturer) consisting of starters, circuit breakers, overload relays, limit switches, control transformer for a 120-volt control circuit, control relays, and controlling devices.
- C. Furnish magnetic controls for motors. Design controls to permit "inching" in both forward and reverse directions under full load, automatically regulated acceleration, and rapid brake response.
- D. Provide each hoist with limit switches of automatic-reset control circuit type to prevent overtravel in both raising and lowering directions.
- E. Compliance: Make all electrical equipment including motors, controls, resistors, brakes plus all conduit, wiring, panels, and enclosures with applicable requirements for materials, workmanship, construction, and installation of latest NEMA and National Electrical Code Standards.

2.15 MOTORS:

- A. Provide in accordance with Section 26 20 00 and as specified herein.

B. Motors for Hoists and Trolley: Totally enclosed, reversible, induction motors especially adapted to hoist service.

1. Enclosure: As indicated in the Hoist Schedule.
2. Insulation: Minimum Class "F" with Class "B" temperature rise, 104 degrees F ambient unless otherwise indicated or specified.
3. Service Factor: 1.15.
4. Provide capacity to start and operate hoists at maximum speed rated capacity indicated without exceeding nameplate ratings for current and power and without operating in the service factor.
6. Provide ball or roller bearings, in accordance with ABMA Standard 9 and Standard 11; minimum L-10 life of 100,000 hours.
7. Premium efficient motors, nominal and minimum motor efficiencies per NEMA MG1.
8. Rating: 460V, 3-phase, 60 Hertz.

2.16 PUSHBUTTON CONTROL:

- E. Provide pendent pushbutton control station with sufficient pushbuttons to control all operations of hoists and trolley. Clearly mark each pushbutton to indicate its function. Make cable long enough to reach within 4 feet of operating floor or platform level with a supporting chain. If necessary, attach an arm to hoist so that pendent cable and pushbutton controls will hang vertically and be readily accessible from operating positions.
- F. Controls for Wound-Rotor Motors: Five-step, full magnetic type. Design all other controls to be designed for single-speed motors.
- G. Provide hoist control as indicated in Hoist Schedule.
- H. Provide hoist with an upper limit switch of automatic reset control circuit type to prevent overtravel.

2.17 CONDUCTORS AND COLLECTORS:

A. Manufacturers:

1. Insul-8-Bar Protected Conductors made by Insul-8-Corp.
2. Safety-T-Bar Conductor Systems made by Howell Corp.
3. Duct-O-Bar Conductor System made by Duct-O-Wire Co. Use equipment and accessories approved by Underwriter's Laboratories (UL).

- C. For conductor for electric current supply use safety type in which conductor is shielded by a molded-plastic cover that surrounds conductor except for a slotted opening shaped to contour of collector head. Provide separate conductor for each phase. (Dual conductors in a single insulating shield are not acceptable.) Make conductor of plated steel or copper designed for carrying maximum anticipated current. Make molded-plastic shield of high dielectric strength, rigid yet sufficiently flexible to permit bending to radius of curves or switches, and resistant to corrosion and deterioration from sunlight or weather. Space insulated supports not over 5 feet on straight track and 3 feet on curves.
- D. Provide weather shield for exterior conductors.
- E. Use collectors of sliding shoe type with an adjustable spring-load arm capable of horizontal or vertical movement to automatically adapt to irregularities of conductor. Set shoe in a molded-plastic head that will prevent external contact with shoe when it is running on conductor. There shall be no exposed bare current-carrying surfaces or wires in collector or arm where shoe is in contact with conductor.

2.20 SHOP PAINTING:

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09 96 00.
- B. Surface preparation, mixing and application and safety requirements shall be in accordance with the paint manufacturer's printed instructions and as specified.
- C. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- D. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

PART 3 - EXECUTION

3.01 TRAINING:

- A. Provide training in accordance with specification Section 01 78 25.

3.02 INSTALLATION:

- A. Install items in accordance with manufacturer's printed instructions and as indicated and specified.
- B. Check horizontal and vertical alignment of track and rails.

- C. Erect rack level throughout, with section ends machined fitted and spliced with web-type couplings to provide flush level connections. Maximum gap between adjacent ends not exceeding 1/16-inch.
- D. Do not use cast fittings.

3.03 FIELD TESTING:

- A. Provide in accordance with Section 01 78 25.
- B. Perform all tests with instrumentation controls and motor controls. Perform testing in accordance with OSHA 29 CFR 1910.179 and as specified herein.
- C. After installation of hoist equipment, and after inspection, operation, testing and adjustment have been completed by manufacturer's field service technician, conduct test for each hoist in presence of the Engineer to determine its ability to operate at rated speeds and capacity under conditions specified and indicated. During tests, observe and record, capacity and motor inputs. Promptly correct or replace all equipment not conforming to the requirements of this section revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results are obtained. Contractor to provide all labor, weights and materials for conducting tests.
 - 1. Provide a 60 minute test for each hoist.
 - 2. Running test shall consist of moving hoist and trolley through two complete cycles. The first cycle will be with no load. For the second cycle, the unit will be loaded with 100 percent of the specified load rating.
 - 3. Test and simulate all limit switches, locking and safety devices.
- D. Make all adjustments to place equipment in specified working order at time of above tests.
- E. After three (3) unsuccessful testing attempts, remove and replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated.

3.04 FIELD TOUCH-UP PAINTING:

- A. After installation and testing, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.05 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

3.06 HOISTING SCHEDULE

Hoist Type	Service
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Wire Rope Monorail Hoist and Trolley	Chlorine Gas
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A. Performance and Design Requirements

1. Chlorine Gas

- a. Type: Wire Rope Monorail Hoist and Trolley
- b. Hoist Suspension Type: Underhung Motorized Trolley
- c. Design Capacity: 2.5 tons
- d. Max Unit Weight: 750 lbs
- e. Drive: Variable Frequency Drive (VFD)
- f. Lift: 20 ft
- g. Beam Flange: 4-inches
- h. Hoist Control Type: Two-Speed
- i. Trolley Control Type: Two-Speed
- j. Operating Voltage: 460 V, 3 phase, 60 Hz
- k. Hoist and trolley to include a control pendent.

END OF SECTION

SECTION 43 21 00.23

PROCESS PUMPS AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test process pumps, motors, drives, and appurtenances as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- B. American National Standards Institute (ANSI):

- 1. S1.11: Standard Octave-Band and Fractional-Octave-Band and Digital Filters.

- C. ASTM International (ASTM):

- 1. A36/A36M: Standard Specification for Carbon Structural Steel.
 - 2. A48/A48M: Standard Specification for Gray Iron Castings.
 - 3. A108: Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
 - 4. B584: Standard Specification for Copper Alloy Sand Castings for General Applications

- D. Hydraulic Institute (HI):

- 1. Current Standards.
 - 2. 14.6: Rotodynamic Pumps for Hydraulic Performance Acceptance Tests

- E. National Electrical Manufacturers Association (NEMA):

- 1. MG1: Motors and Generators.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00:

- 1. Data regarding pump and motor characteristics and performance:
 - a. Prior to fabrication and testing, provide guaranteed performance curves based on actual shop tests of mechanically duplicate pumps, showing they meet indicated and specified requirements for head, capacity, horsepower, efficiency and NPSHr.

- (1) For units of same size and type, provide curves for a single unit only.
 - b. Performance curves shall include maximum pump speed indicated and specified for each service showing maximum and minimum impeller diameters available, acceptable operating range (AOR) and preferred operating range (POR).
2. Characteristic curves for variable speed pumps. Identify curves by speed and provide all curves on one sheet. Provide NPSH_r curve for each speed.
3. Shop drawing data for accessory items.
4. Certified setting plans, with tolerances, for anchor bolts.
5. Manufacturer's literature as needed to supplement certified data.
6. Operating and maintenance instructions and parts lists.
7. Bearing temperature operating range for the service conditions specified.
8. List of recommended spare parts other than those specified.
9. Shop and field inspection reports.
10. Bearing Life: Certified by the pump manufacturer. Include design data.
11. Recommendations for short and long-term storage.
12. Number of service person-days provided and per diem field service rate.
13. NSF certification.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.
- B. Provide spare parts that are identical to and interchangeable with similar parts installed as follows:
 1. One complete set of gaskets and O-rings for every pump as applicable.
 2. For pumps with packing, one complete set of spare packing for each pump of differing style and capacity. Include lantern ring for each packing set.
 3. For pumps with mechanical seals:
 - a. One mechanical seal repair kit and restriction brushing for each pump of differing style and capacity.

b. One spare mechanical seal for each pump of differing style and capacity.

4. One set of any special tools required for maintenance of each pump style

1.05 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

B. Pumps of the same type shall be the product of one manufacturer.

C. Pumps shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.

D. Welding: In accordance with latest applicable American Welding Society Code or equivalent.

E. The Contractor shall obtain the pumps, motors, and appurtenances from the pump manufacturer, as a complete and integrated package to insure proper coordination and compatibility and operation of the system.

1. Variable frequency motor controllers can be supplied by the Contractor or the pump manufacturer at the Contractor's option. The pumping system must be a complete and integrated package to insure proper coordination and compatibility and operation of the system.

a. The Contractor shall coordinate the variable frequency motor controllers with the pump and motor manufacturer and submit as part of the shop drawings a written statement signed by the Contractor, pump manufacturer, motor manufacturer and variable frequency motor controller manufacturer that the variable frequency motor controller manufacturer has received the required information from the pump and motor manufacturers and that all parties have reviewed the system and coordinated the equipment selection. Also include all motor data and information that has been used for the coordination.

b. Provide variable frequency motor controllers in accordance with Section 26 29 23.

F. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.

G. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.

2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping, electrical and miscellaneous utility connection:
 - a. All pumps not listed below: 1 person-days.
 - (1) Sample pumps: Not required
 - (2) Chemical drum transfer pumps: Not required
 3. Functional Testing, Performance Testing, and Owner Training: Calibrate, check alignment and perform a functional test with water. Perform field performance. Provide Training to Owner personnel.
 - a. End suction centrifugal pumps: 3 person-days
 - b. Screw centrifugal pumps: 2 person-days.
 - c. Dry pit submersible pumps: 1 person-days
 - d. Vertical inline pumps: 1 person-days
 - e. Magnetic drive pumps: 2 person-days
 - f. Sample pumps: Not required.
 - g. Chemical drum transfer pumps: Not required.
 4. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 5. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
- H. Manufacturer of pumps shall have a minimum of five (5) operating installations with pumps of the size specified and in the same service as specified operating for not less than five (5) years.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- B. Pump capacities and operating data are indicated in the Process Pump Schedule.
- C. Pumps normally operate with a flooded suction except that pumps will be subject to a suction lift if indicated in the Process Pump Schedule.

2.02 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. The Contractor shall conform to the seismic design requirements for this project and for the work of this specification section.
- C. Provide all equipment bases, anchorage, supports and foundations designed in accordance with the seismic requirements indicated and specified.
- D. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were performed and that all components have been sized for the seismic forces specified and indicated.

2.03 PUMP CONSTRUCTION – GENERAL:

- A. All wetted pump materials, including mechanical seals must be NSF 61 approved.
- B. Pumps: Provide type, arrangement and drive as indicated in the Process Pump Schedule.
- C. Design and proportion all parts of pump specially adapted for the service specified and indicated.
- D. Pump Mounting:

1. Horizontal Pumps:

- a. Mount each pump and drive on a common base.
 - (1) Material: ASTM A36/A36M fabricated structural steel.
 - (2) Provide structural steel shape bases for pumps 4-inch and larger and bent form bases for pumps smaller than 4-inch unless otherwise specified.
 - (3) Provide bases with provisions for grouting and for anchor bolts.
 - (4) Design baseplates to support pump and driver.

- (5) Provide planed surfaces of bearing pads for pumps and drives.
- E. Design casings for removal of rotating parts without disconnecting suction and/or discharge piping.
- F. Provide lifting devices on pump casings for handling.
- G. Provide ribs or reinforcing required to withstand the specified hydrostatic test pressure, to prevent deflection caused by hydraulic thrust and to support the motor.
- H. Provide components with machined registered concentric shoulder fits for precision alignment. Equipment without registered fits is not acceptable.
- I. Seals:
 - 1. Provide split mechanical seals for all direct coupled pumps unless otherwise specified.
 - 2. Split mechanical seal:
 - a. Manufacturer: Chesterton Style 442.
 - b. Materials:
 - (1) Gland: Type 316 stainless steel.
 - (2) Rotary Holder: Type 316 stainless steel.
 - (3) Hardware: Type 316 stainless steel.
 - (4) Springs: Hastelloy C or Elgiloy.
 - (5) Rotating Faces: Silicon Carbide.
 - (6) Stationary Faces: Silicon Carbide.
 - (7) Elastomers: Viton.
 - (8) Restriction Bushing: Split type, glass filled teflon.
 - c. For pumps specified and indicated not requiring seal water, provide Enviroseal Spiraltrac bushing version D, type A.
 - (1) For vertically mounted pumps provide seal vent as indicated and in accordance with API Plan 13.
 - d. For pumps specified and indicated requiring seal water, provide seals with flushing water from a clean external source.

J. Couplings:

1. Non lubricated, polyurethane flex material type.
2. Split design.
3. Spacer type.
4. Manufacturer: Rexnord Omega or acceptable equivalent product.
5. Provide guards for protection for personnel, conforming to OSHA requirements.
 - a. Guards and Hardware: Type 316 stainless steel.

2.04 HORIZONTAL END SUCTION CENTRIFUGAL PUMPS:

A. Manufacturers:

1. Aurora
2. Cornell
3. FlowserveType: Non-overloading, single stage volute centrifugal pumps. Direct coupled to motor.

C. Materials of construction

1. Casing, Bearing Frame and Seal Plate: ASTM A48/A48M Class 30 cast iron.
2. Impeller: Type 316 stainless steel.
 - a. Enclosed, dynamically balanced.
3. Shaft: Steel ASTM A108-C1141.
4. Sleeves: Type 316 stainless steel.
5. Bearing: Grease lubricated ball bearings.

D. Mechanical Seals:

1. Provide as specified herein.

E. Motors: Provide as specified herein and in Section 26 20 00.

F. Couplings: Provide as specified herein.

G. Baseplates: Provide as specified herein.

2.05 MAGNETIC DRIVE PUMPS FOR CHEMICAL SERVICE:

A. Manufacturers:

1. March Pump
2. Sundyne Ansimag
3. Iwaki America
4. Finish Thompson

B. Type: Pumps shall be a self-priming, seal-less magnetic drive unit with isolated housing container and suitable for the chemical being pumped. Chemical shall be pumped without direct connection with the motor. Pump shall be suitable for the application shown on the Drawings and specified.

C. Materials must be selected by the pump manufacturer based on compatibility with a 3,000 mg/l solution of sodium hypochlorite as well as a 5,000 mg/l solution of citric acid

D. Motors: Provide as specified herein and Section 26 20 00.

E. Baseplates: Provide as specified herein.

2.06 VERTICAL MULTISTAGE PUMPS:

A. Manufacturers:

1. Aurora
2. GrundfosType: Non-overloading, vertical multistage centrifugal pumps. Direct coupled to motor.

C. Materials:

1. Impellers, Shaft, Diffuser Chambers and Sleeve: Type 316 stainless steel
2. Suction and Discharge: Type 316 Stainless Steel
3. Bearings: Ceramic
4. Bearing Ring: Tungsten Carbide
5. O-Rings: EPDM
6. Wear Ring: Teflon
7. Motor Bracket: ASTM A48/A48M Class 30 cast iron

- 8. Hardware: Type 316 stainless steel
 - 9. Mechanical Seals: Tungsten carbide x tungsten carbide, EPDM elastomers and Type 316 stainless steel metallic components
 - D. Motors: Provide as specified herein and in Section 26 20 00.
- 2.07 SAMPLE PUMPS
- A. Manufacturers
 - 1. Grundfos Scala 2 Variable Speed Booster Pump
 - 2. Approved Equal.
 - B. Capable of self-priming no less than 20 feet.
 - C. Integral control touchpad.
 - D. Materials: Specified manufacturer standard materials.
- 2.08 SOLIDS HANDLING SCREW CENTRIFUGAL PUMPS
- A. Manufacturers
 - 1. Hidrostal
 - 2. Vaughn
 - 3. KSB
 - B. Type: Solids handling single-single stage horizontal screw centrifugal pumps
 - C. Pump Casing
 - 1. Material:
 - a. Cast Iron ASTM A48 Class 40
 - 2. Provide high point of casing with an air vent and low point with a drain.
 - 3. Provide pump casing with a replaceable suction piece or suction liner.
 - a. Liner or Suction Piece Material
 - (1) Cast Iron ASTM A48 Class 40
 - b. Provide with internal straight sides allowing even axial adjustment of the impeller clearance

- c. Provide with spiral grooves providing a cutting action with impeller vane.
- d. Provide external adjustment of impeller clearance without the need to drain the pump casing or suction piping.

D. Bearing Frame

- 1. Cast Iron ASTM A48 Class 40
- 2. Fit to casing with machined registered joints.
- 3. Provide main frame designed to resist without distortion, all stresses due to impeller thrust and bearing loads.
- 4. Provide main frame designed to support shaft and impeller and to contain stuffing box and bearings.

E. Bearings:

- 1. Grease lubricated anti-friction type
- 2. Outboard bearing to be combination thrust and radial type; inboard bearing radial type
- 3. Provide bearings in a dust and moisture proof enclosures
- 4. Provide means in bearing housing, such as removable plug diametrically opposite grease fitting, to prevent over greasing of bearing.
- 5. Provide bearings with a minimum B-10 life rating of 100,000 hours at specified operating conditions and 40,000 hours minimum at 25 percent of the BEP at highest speed, based on latest ABMA and ANSI Standards.

F. Pump Shaft

- 1. ASTM A276 Type 420 stainless steel
- 2. Protect shaft from wear at stuffing box and from contact with pumped liquid by removable and replaceable sleeve.
- 3. Sleeves
 - a. Extend sleeves through stuffing box
 - b. For pumps equipped with mechanical seals: Type 316 stainless steel or ASTM A743 Grade CA-15 stainless steel, 300-350 BHN.

G. Impeller

1. Type: Screw type solids handling single suction combining the action of a positive displacement screw and single vane centrifugal impeller
2. Provide spiral grooves or pump out vanes on the impeller flange.
3. Material
 - a. High Chrome Iron ASTM A532 Type III A, 450 BHN
4. Provide impeller leading edges hardened to a minimum 450 brinell hardness (Rc47) for high chrome impellers.
5. Provide tapered fit and streamlined bolt capable of holding in event of motor reversal under full torque.
 - a. Impeller Bolt: Type 4120 stainless steel
 - b. Impeller fasteners: Type 416 stainless steel
6. Statically and dynamically balance each impeller.

H. Seals: As specified herein.

I. Couplings

1. Non lubricated, polyurethane flex material type.
2. Split design.
3. Spacer type.
4. Manufacturer: Rexnord Omega or acceptable equivalent product.
5. Provide guards for protection for personnel, conforming to OSHA requirements.
 - a. Guards and Hardware: Type 316 stainless steel

J. Motors

1. Provide as specified herein and Section 26 20 00.

2.09 DRY PIT SUBMERSIBLE PUMPS

A. Manufacturers

1. Pentair (Fairbanks) 5730 Series
2. Flowserve MSX Series

3. Flygt N-Pump Series
4. ABS (Sulzer) XFP Series

B. Pump Construction

1. Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts or bolts shall be of stainless steel construction.
2. Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton rubber O-rings.

C. Configuration

1. Pump shall be capable of operating in a continuous non submerged condition in the vertical position in a dry pit installation.
2. Pump shall be permanently connected to inlet and outlet pipes.
3. Pump shall be of submersible construction and shall continue to operate satisfactorily should the dry pit be subjected to flooding.

D. Impeller

1. Gray cast iron, ASTM A-48 Class 35, dynamically balanced, non-clog design.
2. Provide a semi-austenitic CrNi Stainless Steel VG 434 (A890 Grade 5A) impeller wear ring.

E. Shaft

1. Stainless steel ASTM A-479 S43100-T or ASTM A-276 Type 420 Stainless Steel.
2. Pump and motor shaft to be same unit, with pump shaft an extension of the motor shaft.
3. Shaft sleeves must be Stainless Steel ASTM A-276 Type 420 Stainless Steel.

F. Volute / Suction Cover

1. Single piece gray cast iron, ASTM A-48, Class 35B, nonconcentric design with smooth passages of sufficient size to pass any 1-inch solids that may enter the impeller.

G. Bearings

1. Pump shaft to rotate on two bearings.

2. Sealed and permanently grease lubricated with high temperature grease.
3. Upper bearing: Two row angular contact ball bearing.
4. Lower bearing: Two row angular contact bearing to compensate for axial thrust and radial forces.
5. The minimum B-10 bearing life shall be 50,000 hours at any useable portion of the pump curve.

H. Mechanical Seals

1. As specified herein.

I. Motors

1. Provide as specified herein and Section 26 20 00.

2.10 CHEMICAL DRUM TRANSFER PUMPS

A. Manufacturers

1. Lutz Drum Pump
2. Approved Equal

B. Provide 10-feet of 1-inch PVC tubing with each pump.

C. Must be compatible with 12.5% sodium hypochlorite and 50% citric acid solutions.

D. 120V single phase drive with integral extension cord and plug.

2.11 MOTORS:

A. Provide in accordance with Section 26 20 00 and as specified and indicated.

B. Horsepower rating of motors: Not less than maximum brake horsepower requirements of pumps under any condition of operation specified and indicated without operating in the motor service factor.

C. Motor enclosure and motor speed: As indicated in the Process Pump Schedule.

D. For flex-coupled pumps, provide motors with base supports with machined registered joints for mounting on pump motor support.

E. Provide motors for horizontal pumps with mounts for bolting to baseplate.

F. In addition to the requirements for bearings specified under Electric Motors in Section 26 20 00, provide pump motors for pumps of 10 HP and more with ball or roller

bearings. Provide vertical motors with at least one bearing designed for thrust with bearings. Provide bearing with a minimum B-10 life of 100,000 hours.

- G. Service Factor: 1.15, with 1.0 inverter duty rating for pumps equipped with variable frequency motor controllers.
- H. Premium efficiency with nominal and minimum efficiencies per NEMA MG1.
- I. Site Altitude: 4,635 feet above sea level.
- J. Provide Inpro/Seal bearing isolators.

2.12 DRAIN AND VENT PIPING:

- A. Provide drains from stuffing box, air release valves, and casing vent and drain piping and valves to discharge into floor drains or sumps.
- B. Provide pipe and fittings in accordance with Section 40 23 19.05 and as indicated.

2.13 GAUGES:

- A. Provide gauges assemblies for suction and discharge of each pump in accordance with Section 40 23 19.05 and as indicated.

2.14 SHOP PAINTING:

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09 96 00.
- B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install items in accordance with accepted shop drawings, manufacturer's printed instructions and as indicated.
- B. Install pumping units on a concrete pad and align thereon.
 - 1. Coupling halves must be disconnected and only reconnected after alignment.
 - 2. Set base on metal shims placed directly under the part of the base carrying the greatest weight and spaced close enough to provide uniform support.

- C. Horizontal pumps: Dowel pump and drive to baseplate after alignment in field to facilitate realignment after disassembly.
 - D. Final Coupling Alignment:
 - 1. Perform only after base is installed and piping is connected and pump nozzle connections tested in accordance with paragraph 3.02.
 - 2. If realignment is required piping must be disconnected prior to alignment, piping reconnected and alignment checked prior to connecting coupling halves.
 - E. After alignment is correct, grout using high grade non-shrink grout.
 - 1. For horizontal pumps fill entire base and leave no gaps or voids.
 - 2. Do not imbed leveling nuts in grout.
 - F. Provide 316 SST wall mounted bracket for hanging each chemical drum transfer pump adjacent to their respective chemicals.
- 3.02 FIELD TESTING:
- A. Comply with the requirements specified in Section 01 78 25 and as specified herein.
 - B. Test piping connections to prove the pump nozzle are installed with the pipe in a free supported state and without need to apply vertical or horizontal pressure to align piping with pump nozzles. This must be performed and the piping acceptable prior to any field performance testing.
 - C. After installation of pumping equipment, and after inspection, operation, testing and adjustment have been completed by the manufacturer's field service technician, conduct running test for each pump in presence of the Engineer to determine its ability to operate within the vibration and temperature limits specified, and to deliver its rated capacity under specified conditions.
 - 1. During tests, observe and record head, capacity, pump bearing housings and motor bearing temperature, noise and vibration and motor inputs.
 - 1. Bearing Temperature: Bearing temperature not to exceed 180 degrees F.
 - 2. Test Duration: Determined by the Engineer, but not less than three hours of continuous operation at each condition specified and indicated.
 - 2. Immediately correct or replace all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.
 - 3. Repeat tests until specified results are obtained.

4. Contractor to provide all water, labor, temporary piping, and equipment for conducting tests.

1. Contractor is responsible for delivery and disposal of water used for testing.

- D. Make all adjustments necessary to place equipment in specified working order at time of above tests.
- E. Test pump on product only. If product is not available, test with water.
- F. Remove all replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the satisfaction of the Engineer that equipment will perform the service specified, indicated and as submitted and accepted.

3.03 FIELD TOUCH-UP PAINTING:

- A. After installation and accepted testing by the Engineer, apply touch-up paint to all scratched, abraided and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

3.05 PUMP SCHEDULE

- A. Chlorination Motive Water Booster Pumps – CIP Tanks Chlorine Supply

1. Number of pumps: 2
2. Type: Vertical Multistage
3. Design Capacity: 15 gpm at 200 ft TDH
4. Drive: Full Voltage Non-Reversing (FVNR)
5. Minimum hydraulic efficiency at max capacity: 60%
6. Connections: 1-inch suction and discharge
7. Power: 1.5 HP maximum, 3 phase, 480 V, 60 Hz
8. Speed: 3600 RPM maximum.

- B. Chlorination Booster Pumps – Disinfection and Emergency Use

1. Number of pumps: 2

2. Type: Vertical Multistage
3. Design Capacity: 30 gpm at 310 ft TDH
4. Drive: Full Voltage Non-Reversing (FVNR)
5. Minimum hydraulic efficiency at max capacity: 60%
6. Connections: 1 1/4-inch suction and discharge
7. Power: 5 HP maximum, 3 phase, 460 V, 60 Hz
8. Speed: 3600 RPM maximum.

C. Backwash Sludge Pumps

1. Number of pumps: 2
2. Type: Screw Centrifugal
3. Design Capacity: 300 gpm at 35 ft TDH
4. Drive: VFD
5. Minimum hydraulic efficiency at design point: 70%
6. Power: 5 HP maximum, 3 phase, 460 V, 60 Hz
7. Speed: 3600 RPM maximum

D. CIP Chemical Waste Pumps

1. Number of pumps: 2
2. Type: Magnetic Drive End Suction
3. Design Capacity: 60 gpm at 50 ft TDH (S.G. 1.02)
4. Drive: FVNR
5. Horsepower: 3 HP maximum, 3 phase, 460 V, 60 Hz
6. Speed: 3600 rpm

E. Backwash Recycle Pumps

1. Number of pumps: 4
2. Type: Horizontal End Suction Centrifugal

3. Design Capacity: 695 gpm at 20 ft TDH
4. Drive: VFD
5. Minimum hydraulic efficiency at design point: 75%
6. Horsepower: 10 HP Maximum
7. Maximum operating speed at rated head: 1800 rpm

F. Coagulant Flash Mix Pumps

1. Number of pumps: 2
2. Type: Horizontal End Suction Centrifugal
3. Design Capacity: 2090 gpm at 30 ft TDH
4. Drive: VFD
5. Minimum hydraulic efficiency at design point: 75%
6. Horsepower: 25 HP maximum
7. Speed: 1800 rpm maximum

G. Sample Pumps

1. Number of Pumps: 5
 1. Ozone Sample Pump 1
 2. Ozone Sample Pump 2
 3. Ozone Sample Pump 3
 4. Ozone Sample Pump 4
 5. Spare Sample Pump 5
2. Type: As specified under “Sample Pump” section.
3. Design Capacity: 1-10 gpm. Adjustable discharge head
4. Power: Fractional HP, 120 V single phase 60 Hz

H. Chemical Drum Transfer Pumps

1. Number of Pumps: 2

2. Pumping application:
 1. 50% strength citric acid transfer
 2. 12.5% strength sodium hypochlorite transfer
 3. Design conditions:
 1. Maximum flow: 21 gpm
 2. Maximum head: 56 feet
 4. Connection: 1" hose barb
 5. Power: Fractional HP, 120 V single phase with power cord.
- I. UF Backwash Supply Pumps (supplied by UF system manufacturer)
1. Number of pumps: 3
 2. Type: Horizontal end suction
 3. Design point as determined by UF system manufacturer.
 4. Drive: VFD
 5. Power: 75 HP maximum, 460 V, 3 phase, 60 Hz
- J. UF CIP System Pumps (supplied by UF system manufacturer)
1. Number of pumps: 2
 2. Type: Horizontal end suction or vertical multistage
 3. Design point as determined by the UF system manufacturer
 4. Drive: VFD
 5. Power: 20 HP maximum, 460 V, 3 phase, 60 Hz
- K. Ozone Injection Water Pumps
1. Number of Pumps: 2
 2. Type: Horizontal end suction or vertical multistage
 3. Design point as determined by the Ozone System Manufacturer
 4. Drive: VFD

5. Power: 40 HP maximum, 460 V, 3 phase 60 Hz

L. Clearwell Drain Pump

1. Number of Pumps: 1

2. Type: Dry pit submersible

3. Design Capacity: 1,000 GPM at 24 feet of head.

4. Minimum hydraulic efficiency at design point: 75%

5. Drive: Constant speed

6. Power: 10 HP maximum, 480V, 3 phase, 60 Hz

7. Speed: 1,200 rpm maximum

END OF SECTION

SECTION 43 21 13

VERTICAL TURBINE PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Work of this section includes vertical turbine type pumps for thirteen (13) Ultrafiltration (UF) Feed Pumps and five (5) High Service Pumps.
- B. Each pump shall be complete with motor, pump column assembly, shafting, bearings, sole plate, discharge head, bowl assembly, anchor bolts, and all other appurtenances specified or required for proper operation. Pumps shall have open line shaft design with water lubricated bearings.
- C. Equipment furnished and installed under this section shall be assembled, erected, and placed in proper operating condition in full compliance with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the engineer.

1.02 REFERENCES:

- A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to Division 01 General Requirements.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00
- B. Product Data
 - 1. Catalog cut sheets and written description of each item describing its operation.
 - 2. Construction materials.
 - 3. Performance curves for entire range of pump for capacity, total dynamic head, brake horsepower, efficiency, and net positive suction head required. Indicate specified conditions.
 - 4. FEA Analysis results as required below.
 - 5. Motor and electrical data.
 - 6. Mechanical seals.
 - 7. Proposed nameplate size, material, and printed information.

C. Shop Drawings

1. Detailed dimensional drawings indicating overall dimensions, elevations, weights, sizes and required clearances.
2. Cross section drawings labeling all interior parts including bearings, seals, and other mechanical parts.
3. Diagrams indicating oil compartments and cooling mechanism.
4. Anchoring and mounting details.

D. Bearing life calculations and certified pump and motor test data as described within this specification.

E. Verification: Submit verification submittal of performance requirements and testing for each pump. Submit verification submittal after initial submittal is approved by the Engineer. Pumping equipment shall not be shipped from the manufacturer until the verification submittal is approved by the Engineer. Verification submittal shall include:

1. The actual performance curves from shutoff to the maximum manufacturer's recommended flow rate of the pump for capacity, total dynamic head, brake horsepower, efficiency, and net positive suction head required.
2. Required test results, motor serial numbers, location, and date of test.

F. Operation and Maintenance Manual: Provide Operation and Maintenance Manuals in accordance with Division 01.

G. The complete pump assembly shall be certified to NSF/ANSI standard 61 and certification must be provided with the submittal. This certification shall cover all wetted components of the pump, including but not limited to the bowl assembly, column assembly, discharge head assembly & suction barrel (when applicable). Manufacturers without NSF61 certification will not be considered.

1.04 SPARE PARTS:

A. Comply with the requirements specified in Section 01 61 00.

B. Spare parts shall be of the same manufacture and quality as those provided with the equipment. Spare parts shall be suitable packaged in accordance with the Manufacturer's recommendations, with labels indicating the contents of each package. Spare parts shall be delivered to the Owner with the equipment of this section.

C. Provide the following spare parts for each pump:

1. One mechanical seal assembly for each pump with mechanical seals.
2. One set of spare packing for each pump with packed glands.

3. One complete set of gaskets
4. One set of wearing rings

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Manufacturer's Qualifications
 1. The pump manufacturer shall have been engaged in the production of the type of equipment being provided for the past 10 years for similar types of applications.
 2. The pump manufacturer shall have provided similar equipment on a minimum of 5 installations of similar type and size in the past 5 years.
- C. Reference Standards: Except as modified or supplemented herein, vertical turbine pumps shall conform to the applicable requirements of ANSI/AWWA E103 and the Hydraulic Institute Standards, current edition.
- D. Testing
 1. Required tests shall be performed for all vertical turbine pumps specified under this section.
 2. Provide for all equipment necessary to perform the tests.
 3. Testing procedures shall be in accordance with HI 14.6 Grade 1U.
 4. Performance test shall be conducted using the pump with its respective driver provided for this project.
 5. Tests shall be conducted by the manufacturer or a manufacturer's certified representative.
 6. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.
 7. Factory Performance Tests
 - a. The pump manufacturer shall afford the opportunity to the Engineer to Factory Witness Test any pump test. Manufacturer shall provide written notice to the Engineer no less than 30 days prior to the start of the factory test period. Travel and per diem costs for Factory Witness Testing will be at the expense of the Engineer.
 - b. Demonstrate that the pumping equipment satisfies the performance requirements of Part 2 of this specification section.

- c. Develop the actual performance curve from shutoff to the maximum flow rate of the pump using a minimum of five points. Actual performance curves shall include the pump full rotation speed and three additional VFD curves at reduced rotation speeds specified by the Engineer during shop drawing review. Use of affinity laws to develop reduced speed curves for the final pump curves is not acceptable.
 - d. Test tolerances: At the specified head the capacity shall be within 10% above the specified capacity and 0% below.
- 8. Factory Hydrostatic Tests
 - a. Test each part of the assembled pump containing fluid under pressure.
 - b. Test pressure: The greater of the following:
 - (1) 150% of the maximum safe working pressure of the flanges.
 - (2) 125% of the head at shutoff.
 - c. Test duration: 30 minutes.
 - d. Zero leakage of fluid shall be evident.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. The pumping equipment shall be completely factory assembled, aligned, and securely crated for shipment. When received at the site, the pumping equipment shall be stored in its shipping container until ready for installation. The pumping equipment shall be stored in a clean, dry, place, and indoors until ready for installation. Equipment shall not be allowed to freeze.

1.07 WARRANTY:

- A. The supplier shall guarantee in writing that the equipment furnished is appropriate for the intended service and shall be free of manufacturing and fabrication defects in material and workmanship for a period of 1 year after the equipment is satisfactorily placed in service.

PART 2 PRODUCTS

2.01 PERFORMANCE AND DESIGN REQUIREMENTS:

- A. Ultrafiltration Feed Pumps
 - 1. Number of pumps: 13

2. Configuration: Parallel operation
3. Design Capacity: 1,800 gpm at 130 ft
4. Drive: Variable frequency drive
5. Minimum hydraulic efficiency at maximum capacity: 80%
6. Max operating speed at rated head: 1800 rpm
7. Horsepower: 75 maximum
8. 10-inch column (0.279-inch thick wall) with 1.5-inch minimum shaft
9. 10-inch discharge

B. High Service Pumps

1. Pumps PMP-0411-2 and PMP-0411-2
 - a. Number of pumps: 2
 - b. Configuration: Parallel operation
 - c. Design Capacity: 3,475 gpm at 245 ft
 - d. Drive: Variable frequency drive.
 - e. Minimum hydraulic efficiency at maximum capacity: 80%.
 - f. Max operating speed at rated head: 1800 rpm.
 - g. Horsepower: 300 maximum
 - h. 12-inch column (0.375-inch wall) with 2.44-inch minimum shaft
 - i. 12-inch discharge.
2. Pumps PMP-0411-3, PMP-0411-4, and PMP-0411-5
 - a. Number of pumps: 3
 - b. Configuration: Parallel operation
 - c. Design Capacity: 6,950 gpm at 245 ft
 - d. Drive: Variable frequency drive.
 - e. Minimum hydraulic efficiency at maximum capacity: 80%.

- f. Max operating speed at rated head: 1800 rpm.
 - g. Horsepower: 600 maximum
 - h. 16-inch column (0.375-inch wall) with 2.44-inch minimum shaft
 - i. 16-inch discharge
- C. Pumps shall be non-overloading for all points on the pump maximum speed curve.
- D. Performance of each pump shall be stable and free from damaging cavitation, vibration, and noise in the operating head range.

2.02 MANUFACTURERS:

- A. Vertical Turbine Pumps:
 - 1. Flowserve
 - 2. Floway
 - 3. National Pump Company
 - 4. American Marsh (WILO USA)

2.03 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. The Contractor shall conform to the seismic design requirements for this project and for the work of this specification section.
- C. Provide all equipment bases, anchorage, supports, and foundations designed in accordance with the seismic requirements indicated and specified.
- D. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were performed and that all components have been sized for the seismic forces specified and indicated.

2.04 PUMP CONSTRUCTION:

- A. Pump Discharge Head
 - 1. Fabricated steel, machined on top, diameter equal to the driving motor diameter (BD) with a register fit for locating the driving motor, and bottom suitable for connecting to the bowl and column assembly. Lifting lugs of sufficient strength to support the weight of the complete unit shall be provided.

2. Fabricated steel housing with a bronze throttle bushing and suitably bored to receive mechanical seal.
 3. Drain tap and seal flush line return tap, vent tap, and vent to can
 4. Ultrafiltration Feed Pumps shall have integral suction and discharge flanges, flat face type, for ANSI Class 150 lbs. 16" suction, 10" discharge.
 5. High Service Pumps shall have integral discharge flange, flat face type, ANSI Class 150 lbs, 12-inch or 16-inch discharge as noted above (suction shall be on Suction Can as specified below).
 6. Upper head shaft Type 416 SS with SS threaded coupling
- B. Suction Can: Provide a suction can of carbon steel with barrel wall of at least 0.375-inch thickness. Top of Suction Can shall act as seat for the base of the pump discharge head and drilled to match ANSI class drilling rated for maximum suction pressure. Provide a gasket O-ring between the can and discharge head base to facilitate seal as recommended by the manufacturer. Can top plate shall be of overall square dimension with 4 anchor bolt holes at the corners for anchorage to a concrete base, with grout allowance. Size as recommended by pump manufacturer. Provide anti-vortex vanes at the bottom and sides of the suction can in accordance with ANSI/HI 9.8.
1. The Suction Can shall be provided with a suction flange connection for a working pressure of 150 psi and shall be sized to match the specified system. Suction flange connection shall be on the same side as the discharge flange.
- C. Column Assembly: Shall be supplied with ASTM A 53 Grade B steel pipe flanged or threaded with bronze bearing retainer equipped with suitable lineshaft bearings for the application. Column bearing spacing shall be such that shaft first critical frequency shall be safely above or below the operating resonant frequency.
- D. Lineshaft
1. Lineshaft and coupling: AISI type 416 stainless steel, with 304 stainless steel couplings.
 2. Size to conform to ANSI B58.1.
 3. Shaft diameter: Size as recommended by manufacturer.
 4. Nominal individual section lengths shall not exceed 5 feet on the Intermediate Pumps Only.
 5. Couplings shall be machined with left-hand thread.
 6. Lineshaft bearings: Cutlass rubber, spaced not more than 5 feet apart and mounted in bronze bearing retainers threaded into the column couplings.

- E. Mechanical Seal: Provide pump with a Chesterton Type 155 Flowserve ISC2-PX-61, with silicon carbide vs. silicon carbide rotary and stationary seal faces in a 316 SS gland and rotary holder with EPR elastomers. The housing shall have a lower bronze throttle bushing. The housing seal chamber shall accommodate a single sleeved balanced mechanical seal suitable for the maximum pressure developed by the pump and temperature of 100-degree F maximum. Seal materials shall be suitable for potable water and ANSI/NSF 61 certified. A balanced seal shall be mounted on a shaft sleeve. The shaft supplied shall be a one-piece bowl, line, and head shaft where practical of 416 stainless steel material Extend SS flushing line tubing from the seal to return to wet well or nearest drain.
- F. Pump Bowl Assembly
1. Bowl: Pump bowl castings shall be of close-grained cast iron ASTM A48 Class 30 or ASTM A536 ductile iron Class 60-40-18 where required to meet the hydrostatic pressure criteria listed above. The water passages shall be free of blowholes, sand holes, and other detrimental defects, shall be lined with porcelain enamel, and shall be accurately machined and fitted. The finished bowls shall be capable of withstanding a hydrostatic pressure equal to twice the head at rated capacity or 1-1/2 times the shut-off head, whichever is greater. The bowl wear rings shall be hardened 17-4 stainless steel with a Rockwell C-Scale Hardness number of 40.
 2. Impeller: The impellers shall be Type 315 stainless steel, enclosed type, and shall be dynamically balanced, and shall be fastened securely to the impeller shaft with taper split bushings of steel. Impellers shall be adjustable vertically by an external means from top of drives. Impeller skirt and series case throat area shall be thick enough to allow for machining and wearing at the time of repair.
 3. Pump Shaft: The pump shaft shall be of A582 Grade 416 Stainless Steel turned, ground and polished with chromium content less than 12%. It shall be supported by bronze bearings of ASTM B505 alloy C84400 above and below each impeller. The suction case bearing shall be grease lubricated and protected by a bronze sand collar of ASTM B584 alloy C83800. The size of the shaft shall be no less than that determined by AWWA E 103, Section A4.4 Paragraph 4.4.2.2.
 4. Bolts and hardware: Stainless steel.
- G. Strainer: Stainless steel basket-type with a net water passage area of at least 4 times pipe size. Strainers are not required for the High Service Pumps.
- H. Analysis (Required for High Service Pumps Only)
1. In order to ensure that neither harmful nor damaging vibrations occur to the pump structure at any speed within the specified operating range, the following analysis shall be required:
 - a. Pump manufacturer shall perform a structural frequency analysis of the above ground structural components utilizing a FEA method to ensure that no

structural natural frequencies are excited to a degree that would cause measured vibration amplitudes at the top of the discharge head to exceed the requirements of ANSI/HI 9.6.4-2009. When deemed necessary by the experience of the manufacturer, the below ground structural components shall also be included in the analysis.

- b. The FEA method should include the use of ProE/Mechanica or an equivalent software. All pump assembly components, including the motor, shall be represented as solid elements, and if idealizations are used in place of solid elements, then a complete description of method for the idealization shall be included in the report. The analysis shall also include all modes of interest and pictorially represent each mode shape. Modes of interest are defined as those structural frequencies that exist below 120% of the maximum operating speed. When significant modifications are required to lower the system's natural frequency, the pump structure's stresses and deflections shall also be reviewed. Analysis reports shall conclude acceptable operation at the analyzed operating speeds. The design critical frequency shall be at least 20% above or below the operating range of the pump.
- 2. Manufacturer to provide documentation of the analysis ensuring that the specified requirements have been met, and that documentation should be signed and stamped by the professionally licensed engineer who performed the analysis work.
- 3. When measured in the direction of maximum amplitude on the pump and motor bearing housings, shall not exceed limits given in the latest ANSI/HI nomograph for the applicable pump type.

2.05 MOTORS:

- A. Provide in accordance with Section 26 20 00 and as specified and indicated.
- B. The electric motors shall be WP-1, 460 volt, 3 phase, 60 Hz, inverter-duty rated vertical solid shaft motors with non-reversing ratchet. Provide a steady bushing on the head shaft at the lower motor end.
- C. Premium efficiency, NEMA Design: B, Code: G, Ambient Temperature: 40 deg C, Service Factor: 1.0 for use with VFD (all pumps). type, roller, or ball, for grease or turbine oil lubrication as recommended by the motor manufacturer. Thrust bearing shall be chosen to handle the continuous down-thrust as specified by the pump manufacturer with an AFMBA B-10 bearing life of 12,320 hours, an L-10 bearing life of 17,500 hours, and an L-50 bearing life of 61,600 hours. Provisions shall be made for momentary up-thrust equal to 30% of rated down-thrust. The thrust value shall be calculated at curve points 75% to 125% of specified, full speed, flow rate.
- D. The motor primary thrust bearing shall incorporate a shield or isolator to prevent damage from VFD harmonics and/or stray electrical currents.

- E. The motor rating shall be such that at design it will not be loaded beyond nameplate rating and at no place on the pump curve shall the loading exceed the service factor.
- F. The motor temperature shall be rated no higher than the allowable operating temperature of the motor thrust and radial bearings and in no case shall it exceed the temperature rating of the insulation class used to wind the motor.
- G. Motors less than 200 hp, provide winding temperature detectors per section 26 20 00. Pump motors shall be provided with a built-in 500-watt, 120 VAC condensate heater. Heater shall operate when motor is not running to reduce condensate.
- H. Motors 200 hp or overs shall be provided with a vibration switch. Switch rating 120 VAC, 2 amps minimum.
- I. Motors 200 hp or over shall have over temperature protection, which shall consist of a minimum of six RTD's embedded in the motor windings and two RTD's at the two bearings. Wiring to an external junction box shall be provided. RTD's shall be 100-ohm platinum three wire elements.
- J. Nameplate: Corrosion-resistant metal. Include connection diagram, voltage, full load amperes, locked rotor amperes, Design B, efficiency, manufacturer name, and date.
- K. Manufacturer: General Electric, US Motors, or equal.

2.06 COATINGS:

- A. Bowl assembly exterior, column piping (interior and exterior), discharge head interior, and all steel and iron wetted surfaces shall receive surface prep and be primed and coated with an NSF 61 certified epoxy system suitable for potable water contact.
- B. All pumping equipment and drive units or motors shall be cleaned and painted at the point of manufacturer with a primer compatible with the field paint to be used.
- C. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces and interior of column and discharge head, NSF 61 high solids epoxy in accordance with Section 09 96 00.
- D. The standard factory coating system is suitable for the motor.

2.07 PROTECTIVE DEVICES:

- A. Provide suitable non-rotating metal guards for all exposed rotating parts. Provide suitable non-rotating guards for all rotating shaft ends, which are exposed and protrude more than 1/2 times the shaft diameter.

2.08 DISCHARGE HEAD DIELECTRIC ISOLATION

- A. Where shown on the Contract Drawings, vertical turbine pumps shall be equipped with flange dielectric isolation kits.

- B. EPDM washers/gasket on underside of sole plate shall be cut from NSF-61 certified material.
- C. Flange gasket shall be Type E, 1/8-inch thick NEMA Grade G-10 reinforced epoxy retainer with two seals of either Teflon or EPDM, NSF61 certified.
- D. Insulating sleeves: 1/32-inch thick NEMA Grade G-10, full length, one for each flange bolt.
- E. Insulating washers: 1/8-inch thick NEMA Grade G-10, two for each flange bolt.
- F. Mechanical washers: 1/8-inch thick Type 316 stainless steel, two for each flange bolt.
- G. Manufacturers:
 - 1. Trojan Insulating Gasket Advance Products and Systems.
 - 2. Or equal.

2.09 SPECIAL TOOLS:

- A. Provide special tools necessary for maintenance of pumps and motors including but not limited to tools required for maintenance of bearings and seals.

2.10 SPARE PARTS:

- A. Provide (1) one set of manufacturer recommended spare parts for each pump unit.

2.11 ANCHOR BOLTS:

- A. The Contractor shall provide the required number and size of anchor bolts and nuts for each pump. Anchor bolts and nuts shall be Type 304 stainless steel. Apply an anti-seizing agent to the threads of the anchor bolts prior to installation of the nuts.

2.12 NAMEPLATES:

- A. All equipment shall have a 24 gauge (minimum) stainless steel nameplate with all typical "nameplate" information.
 - 1. Tag number.
 - 2. Voltage.
 - 3. Full load amperes.
 - 4. Locked rotor amperes.
 - 5. Design.

6. Efficiency.
7. Connection Diagram.
8. Manufacturer name and date.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install as shown on the Contract Drawings, approved shop drawings, and as recommended by the Manufacturer. Each pump shall be aligned and connected to the suction and discharge piping and the concrete base. The sole plate shall be grouted in place with non-shrink grout.
- B. Check condition of bearings in pump and motor. Add lubricant according to manufacturer's recommendations. Provide copper tubing from the pump drains to nearest floor drain. Shimming between machined surfaces is not permitted.

3.02 MANUFACTURER'S SERVICES:

- A. Comply with requirements specified in Section 01 43 00.
- B. A manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services hereunder, travel time excluded:
 1. 2 person-days for the Intermediate Pumps and 1 person-day for the High Service Pumps for installation assistance, inspection, and certification of the installation and 1 person-day for function testing and Owner Training.
- C. After installation supervision and testing services by the manufacturer, the Contractor shall submit to the Engineer, a certification letter on the manufacturer's letterhead and signed by the manufacturer certifying that the equipment was installed per the manufacturer's recommendations. Training of Owner's personnel shall be at such times as requested by the Owner. Additional time required to perform these services shall be at no additional cost to the Owner.

3.03 FIELD TESTING

- A. Comply with the requirements specified in Section 01 78 25 and as specified herein.
- B. After initial startup under the supervision of a qualified representative of the pump manufacturer, a preliminary running-in period will be provided to make field tests and necessary adjustments. The Owner will then operate the pumps for a period of fourteen consecutive calendar days.

- C. At the end of the specified period of operation, the pumps will be accepted if, in the opinion of the Engineer, the pumps have operated satisfactorily without excessive power input, wear, lubrication, or undue attention required for this operation, and if all rotating parts operate without excessive vibration or noise at any operating head, including shutoff.

3.04 FIELD TOUCH-UP PAINTING

- A. After installation and testing, apply touch-up paint to all scratched, abraded, and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.05 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 43 41 16

BLADDER TYPE SURGE TANKS AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test bladder type surge tanks, controls, and appurtenances as indicated and in compliance with Contract Documents.
- B. Bladder type surge tanks specified herein are to be used with finished drinking water and all wetted surfaces, linings, and materials shall be certified NSF 61 for use with potable water.

1.02 REFERENCES:

- A. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1, Rules for Construction of Pressure Vessels
- B. ASTM International (ASTM):
 - 1. A36/A36M: Standard Specification for Carbon Structural Steel.
 - 2. A285/A285M: Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate- Tensile Strength.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00:
 - 1. Complete transient analysis of the system clearly showing transient pressures with and without the surge tank incorporated into the system:
 - 2. Shop drawing data for accessory items.
 - 3. Certified setting plans, with tolerances for anchor bolts, tank weights, full and empty.
 - 4. Manufacturer's literature as needed to supplement certified data.
 - 5. Operating and maintenance instructions and parts lists.
 - 6. Listing of reference installations as specified with contact names and telephone numbers.

7. Certified results of hydrostatic testing.
 8. List of recommended spare parts other than those specified.
 9. Shop and field inspection reports.
 10. Shop test results.
 11. Qualifications of field service engineer.
 12. Recommendations for short and long-term storage.
 13. Special tools.
 14. Number of service person-days provided and per diem field service rate.
 15. Results of field testing.
 16. Manufacturer's product data, specifications, and color charts for shop painting.
 17. Provide a listing of the materials recommended for each service specified and indicated. Provide documentation showing compatibility with process fluid and service specified and indicated.
 18. Provide a scaled drawing for each system showing the tanks and piping including equipment weights, lifting attachments, slings and clearances for equipment removal and maintenance.
 19. Structural design and analysis report for surge tank, anchors, bases, and supports.
 20. Material Certification:
 - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of ten (10) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
 - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
- B. A copy of the contract mechanical process, structural, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification

section. If no changes are required, mark all drawings with “No changes required” or provide a statement that no changes are required.

1. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
- C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in submittal return without review until marked up specifications and justifications are submitted in a complete package.
- 1.04 SPARE PARTS:
- A. Comply with the requirements specified in Section 01 61 00.
 - B. One set of all special tools.
- 1.05 QUALITY ASSURANCE:
- A. Comply with the requirements specified in Section 01 43 00.
 - B. Tanks shall be the product of one manufacturer.
 - C. Tanks shall be manufacturer’s standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.
 - D. Welding: In accordance with latest applicable American Welding Society Code or equivalent.
 - E. Shop tests as specified.
 - F. The Contractor shall obtain the tanks, controls and appurtenances from a surge system manufacturer, as a complete and integrated package to insure proper coordination and compatibility and operation of the system.
 - G. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.

- H. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
1. Service Technician must have a minimum of five (5) years of experience, all within the last seven (7) years, on the type and size of equipment.
 2. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 3. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping, electrical and miscellaneous utility connection:
 - a. 1/2 person-days.
 4. Functional Testing: Calibrate, check alignment and perform a functional test with water. Tests to include all items specified.
 - a. 1 person-days.
 5. Field Performance Testing: Field performance test equipment specified.
 - a. 1 person-days.
 6. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.
 - a. 1/2 person-days.
 7. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 8. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
- I. Manufacturer of surge systems and tanks shall have a minimum of ten (10) operating installations with pumps of the size specified and in the same service as specified operating for not less than five (5) years.
- J. If equipment proposed is heavier or taller, different nozzle arrangement than specified and indicated; provide all structural, mechanical, and electrical revisions at no additional cost to the Owner.

1. If equipment is heavier than specified, the Contractor shall provide all hoisting equipment sized to maintain the minimum safety factor between the specified maximum equipment weight and the lifting capacity of the hoisting equipment indicated and specified.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- A. Surge tank capacities and operating data are indicated herein.
- B. Service
 1. Finished Drinking Water from pumping system.
- C. System consists of (2) tanks, bladders, and valve assemblies.

2.02 MANUFACTURERS:

- A. Bladder Type Surge Tanks:
 1. Charlotte America
 2. Pulsco Inc.
 3. Young Engineering Manufacturing Inc.

2.03 SEISMIC DESIGN REQUIREMENTS:

- A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.
- B. The Contractor shall conform to the seismic design requirements for this project and for the work of this specification section.
- C. Provide all equipment bases, anchorage, bolts, supports and foundations designed in accordance with the seismic requirements indicated and specified.
- D. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were performed and that all components have been sized for the seismic forces specified and indicated.

2.04 SURGE TANK CONSTRUCTION:

- A. Type: Inverted bladder-type vessel suitable for use specified and indicated.
 - 1. Configuration: Vertical
- B. Provide surge tanks constructed of carbon steel for a maximum allowable working pressure as specified and indicated in accordance with the ASME Pressure Vessel Code, Section VIII.
- C. Provide shop fabrication and inspection in compliance with Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code with only the plate steels in Table UCS-23 of said code being used.
 - 1. Provide a corrosion allowance of 1/16-inch or 1/6 of the calculated plate thickness at design pressure whichever is greater.
- D. Provide ASME code stamp, National Board Registration number and pressure rating on tank.
- E. Hydrostatic test surge tanks in accordance with ASME Code for Unfired Pressure Vessels .
 - 1. Provide Form U-1A "Manufacturers' Data Report for Unfired Pressure Vessels" prepared by the tank manufacturer to certify that the tank was built in accordance with ASME Code Rules for the Construction of Unfired Pressure Vessels and inspected by a certified inspector.
 - 2. Test pressure: 225 percent of the design pressure of the tank
- F. Provide the surge tanks with a flanged line connection, supports, lifting lugs, davit for lifting access cover and couplings for a drain and level control system.
- G. Provide the surge tanks with a minimum 18-inch diameter access port.
- H. Provide the structural design and supports including the tank, supports, and anchor bolts based upon local building codes in addition to the following criteria:
 - 1. Design for a hydrostatic operating pressure and test pressure as specified herein with no reactive load permitted through the inlet/outlet piping.
 - 2. Support tank by four (4) support legs for attaching to concrete foundation.
 - a. Weld the support legs to the tank.
 - 3. Material: ASTM A36/A36M or ASTM A285/A285M, Grade C.
 - 4. Seismic Design Parameters as specified and indicated

5. No wind design required.
- I. Provide a 1/2-inch (13 mm) threaded connection at the top of the tank with a gas charging valve and pressure gauge assembly.
- J. Tank shell: Construct of deep drawn carbon steel double welded domes and side shells with double welded seams.
- K. Provide tanks equipped with an inverted heavy duty rubber bladder with protective coating for aggressive water.
 1. Bladder material: Butyl, Neoprene, Natural Rubber
 2. Provide NSF 61 approved bladder material.
- L. The precharge pressure will be located inside the bladder. Provide the top manhole removable to allow inspection and maintenance of the bladder.
- M. Provide the bladder sized to conform to the inner shape of the vessel.
- N. Provide OSHA access ladder, cage, and platform with handrail on top of tank for access to gas filling valve and bladder, provide components of aluminum in accordance with Section 05 50 00.
- O. Provide davit for lifting top access port.

2.05 SURGE TANK SCHEDULE:

Surge Tank Service	Finished Drinking Water
Number of Tanks	2
Tag Number:	20-SBT-01 & 20-SBT-02
Tank volume, cubic feet	350
Nominal Tank Diameter, inch	96
Nominal Overall Height, inch	132
Pressure:	
Operating Pressure psi	150
Test Pressure, psi	225
Tank Configuration:	Vertical
Number of Support Legs:	4
Tank Inlet/Outlet Pipe Size:	12-inch, flanged Class 150
Drain Size:	2-inch flanged Class 150

2.06 LEVEL MONITORING

- A. Level monitoring shall be via pressure differential transmitter. Pressure differential transmitter shall be Rosemount Model 3051 digital pressure transmitter. Transmitter shall be two-wire, capacitance (DP/GP) or piezoresistive (AP/GP), high performance differential/gage/absolute/level/flow pressure transmitter with HART® based fieldbus

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based digital communication capabilities. Pressure transmitter shall be NEC 501-5, NEMA code ICS6 and FM certified and have 4-20 mA output signal. Pressure differential transmitter shall be hard mounted on the tank and shall be set for a differential pressure range of -250 to 250 inH₂O. Pressure transmitter shall be NSF 61 certified.

2.07 SHOP PAINTING:

- A. Primer and Finish Paint: Shop apply to all tank interior and exterior ferrous surfaces, high solids epoxy in accordance with Section 09 96 00 High Performance Coatings. Any coatings in contact with finished water shall be NSF 61 certified for drinking water applications.
- B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

2.08 SHOP TESTING:

- A. Comply with the requirements specified in Section 01 75 13 and as specified herein.
- B. Tank Tests:
 - 1. Hydrostatically test tanks as specified.
 - 2. In the event that specified tests indicate that tanks will not meet specifications, Engineer has the right to require additional complete witnessed tests for all tanks at no additional cost to the Owner.
 - 3. Repeat tests until specified results are obtained.
 - 4. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install items in accordance with accepted shop drawings, manufacturer's printed instructions and as indicated.
- B. Install tanks and supports on a concrete pad and align thereon.
 - 1. Install as indicated.

3.02 FIELD TESTING:

- A. Comply with the requirements specified in Section 01 75 13 and as specified herein.
- B. Test piping connections to prove the tank nozzle are installed with the pipe in a free supported state and without need to apply vertical or horizontal pressure to align piping with tank nozzles. This must be performed and the piping acceptable prior to any field performance testing.
- C. Field testing will not be conducted without an accepted procedure, calibration certificates for all testing equipment, gauges, and flow meters and a completed and signed pretesting check list. See Division 1 for checklist.
- D. After installation of surge system, and after inspection, operation, testing and adjustment have been completed by the manufacturer's field service technician, conduct running test for each system in presence of the Engineer to determine its ability to operate within the limits specified, and to function under specified conditions.
 - 1. Provide testing consisting of functional test of the level control system and a simulated power failure when pumps are running at maximum operating flow conditions prior to actual operational testing with pump field performance testing.
 - a. Test Duration: Determined by the Engineer, but not less than three hours of continuous operation at each condition specified and indicated.
 - 2. Immediately correct or replace all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.
 - 3. Repeat tests until specified results are obtained.
 - 4. Contractor to provide all water labor, piping, testing equipment, equipment, flow meters and test gauges for conducting tests.
 - a. Contractor shall provide calibrated test gauges for all permanently installed gauges and portable calibrated flow meters for all pumping systems even in those cases where permanent flow meters are installed.
 - b. All calibrations must be within 30 days of the field testing.
 - c. The testing will not be started and will not be accepted until the calibrated testing equipment stated above is operational and all certifications have been submitted.
 - d. Contractor is responsible for delivery and disposal of water used for testing.
- E. Make all adjustments necessary to place equipment in specified working order at time of above tests.

- F. Test on product only. If product is not available, test with water. Water for testing furnished by Contractor.
- G. Remove all replace equipment at no additional cost to the Owner with equipment that will meet all requirements specified and indicated if unable to demonstrate to the satisfaction of the Engineer that equipment will perform the service specified, indicated and as submitted and accepted.

3.03 FIELD TOUCH-UP PAINTING:

- A. After installation and accepted testing by the Engineer, apply touch-up paint to all scratched, abraided and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 43 41 43

POLYETHYLENE STORAGE TANKS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Work of this Section includes, but is not limited to:
 - 1. Polyethylene chemical storage tanks and appurtenances.
 - 2. Accessories: Bolts, anchor bolts, washers, supports, hold down lugs, ladder as required.
 - 3. The tanks will be used to store chemical solutions as specified in this Specification, paragraph 2.2 Schedule.
 - 4. Provide chemical storage system complete in details and before acceptance each chemical system shall be fully operational and ready for use by the Owner.
- B. The Contractor shall furnish and install as outlined in the Specification Polyethylene Upright Storage Tanks with integrally molded flanged outlet, and accessories complete in place, as shown on the Drawings and as specified herein.
- C. Storage Tanks shall be rotationally molded conform to ASTM D1998 and shall be classified according to the resin
 - 1. All Chemical Tanks: Cross Linked Polyethylene (XLPE).

1.02 REFERENCES:

- A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to Division 01 General Requirements.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B-16.5: Pipe Flanges and Flanged Fittings
- C. ASTM International (ASTM):
 - 1. D638: Standard Test Method for Tensile Properties of Plastics
 - 2. D648: Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
 - 3. D790: Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

4. D883: Standard Terminology Relating to Plastics
5. D1505: Standard Test Method for Density of Plastics by the Density-Gradient Technique
6. D1693: Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
7. D1998: Standard Specification for Polyethylene Upright Storage Tanks

D. International Code Council:

1. International Building Code, 2021 Edition (IBC)

E. Association of Rotational Molders (ARM):

1. Standard Low Temperature Impact Resistance

F. National Sanitary Foundation (NSF):

1. 61: Drinking Water System Components - Health Effects

G. National Fire Protection Association (NFPA):

1. 704: National Fire Rating System (NFR).

H. Occupational Safety and Health Association (OSHA):

1. 29 CFR Part 1910.27 Fixed Ladder
2. 29 CFR Part 1926.104 Safety Belts, Life Lines and Lanyards
3. 29 CFR Part 1926.500 Fall Protection
4. 29 CFR Part 1926.501 Fall Protection
5. 29 CFR Part 1926.502 Fall Protection

1.03 SUBMITTALS:

- A. Provide in accordance with Section 01 33 00.
- B. All submittals shall conform with the requirements of the Contract Documents.
- C. Drawings and Data: The manufacturer's shop drawings shall be approved by the Engineer prior to the manufacturing of the tank(s). Data and specifications for the equipment shall include, but shall not be limited to:
 1. Resin Manufacturer Data sheet

2. Layouts and assembly schedules for each tank identifying dimensions, nozzle size, location, fitting material, rating, and type.
3. Details of inlet and molded outlet fitting, manways, flexible connections, and vents.
4. Gasket style and material, bolt material.
5. Details of all clips and lugs for pipe brackets, anchor bolts, hold down lugs.
6. Details of structural support members. Tank restraint, the drawings and calculations for the system are to be provided and stamped by the supplier.
7. Tank capacity (gallons), weight, empty and filled with product.
8. Maximum design specific gravity.
9. Statement the fabrication shall be in accordance with ASTM D1998, where applicable.
10. Certification that the equipment supplied is manufactured from materials suitable for the intended storage service.
11. Prior to the manufacture of the tanks, the designed wall thickness shall be supplied based upon 600 psi hoop stress (ASTM D1998) at 100-degrees F.
12. Factory Test Report: Upon completion of the tank the manufacturer's inspection report is to be supplied for each tank:
 - a. Verification of wall thickness
 - b. Impact test
 - c. Degree of Crosslinking Test (%Gel -Type I Resin Only), ASTM D2765 Method C
 - d. Verification of fitting placement
 - e. Hydrostatic Test
 - f. Visual inspection
 - g. Verification of materials
13. Manufacturer's Warranty
14. Supporting documentation of Manufacturer's certification to NSF/ANSI 61
15. Manufacturer's unloading procedure

16. Manufacturer's installation instructions

1.04 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Manufacturer shall be ISO 9001 certified. The items specified under this Section shall be furnished by manufacturers who have been regularly engaged in the design and manufacturing of integrally molded flanged outlets of rotationally molded chemical storage tanks based upon ASTM D 1998 using XLPE and LPE and shall have a record of successful installations for the past 10 years. All products shall be suitable for the use noted on the Drawings.
- B. Tanks shall be manufactured from virgin materials. Tanks shall be manufactured from materials certified to NSF/ANSI Standard 61 for chemical storage and submit form from NSF supporting chemical certification.
- C. Tolerances:
 - 1. The tolerance for the outside diameter, including out of roundness, shall be per ASTM D1998.
 - 2. The tolerance for fitting placements shall be +/- 0.5 inches in elevation and 2-degrees radial at ambient temperature.
- D. Conform to the requirements of the manufacturer's field services paragraph 1.5 of the Quality Control Section.
- E. Provide components of manufacturers' latest and proven design. Clean tanks internally prior to shipping. Provide a polyethylene shrink wrap on tank prior to shipment.
- F. Reference Standards
 - 1. ASTM D618 Conditioning Plastics and Electrical Insulating Materials for Testing
 - 2. ASTM D638 Test Method for Tensile Properties of Plastics.
 - 3. ASTM D695 Test Method For Compressive Properties of Rigid Plastics.
 - 4. ASTM D790 Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulation Material.
 - 5. ASTM D883 Definitions of Terms Relating to Plastics.
 - 6. ASTM D1505 Density of Plastics by the Density-Gradient Technique
 - 7. ASTM D1525 Test Method for Vicat Softening Temperature of Plastics
 - 8. ASTM D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics
 - 9. ASTM D1998 Standard Specification for Polyethylene Upright Storage Tanks

10. ASTM D 2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impresser.
11. ASTM D2765 Degree of Crosslinking in Crosslinked Ethylene Plastics as Determined by solvent Extraction
12. ASTM D2837 Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
13. ASTM D3892 Practice for Packaging/Packing of Plastics
14. ASTM F412 Definitions of Terms Relating to Plastic Piping Systems
15. ARM (Association of Rotational Molders) Standards: Low Temperature Impact Resistance (Falling Dart Test Procedure)
16. ANSI Standards B16.5 Pipe Flanges and Flanged Fittings
17. OSHA Standards: 29 SFR 1910.106 Occupational Safety and Health Administration, Flammable and Combustible Liquids
18. NSF/ANSI Standard 61- Drinking Water system Components (Type II resin)
19. ANSI B16.5: Pipe Flanges and Flanged Fittings
20. IBC 2012

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.
- B. Handling, delivery, and storage of the equipment of this Section shall be in accordance with the manufacturer's recommendations.

1.06 WARRANTY:

- A. The supplier shall guarantee in writing that the equipment furnished is appropriate for the intended service and shall be free of manufacturing and fabrication defects in material and workmanship for a period of 5 years from the date of shipment.

PART 2 - PRODUCTS

2.01 POLYETHYLENE STORAGE TANKS

- A. Manufacturers: PolyProcessing, Assmann Corporation of America, or Snyder Industries Inc.

- B. Reference Standard: Tank shall be constructed in conformance with ASTM D1998. Tanks shall be rotationally-molded, crosslinked polyethylene (XLPE) one-piece seamless construction, cylindrical in cross-section and vertical with flat / sloping bottoms in axis.
- C. The material used shall be virgin polyethylene resin as compounded and certified by the manufacturer. Crosslinked polyethylene (XLPE) resin shall be as manufactured by ExxonMobil chemical, or resin of equal physical and chemical properties.
- D. Tanks shall be adequately vented as prescribed per manufacturer recommendation, Venting-Design for ACFM (air cubic feet per minute). Vents must comply with OSJA 1910.106 (f) (2) (iii). All tanks must be vented for atmospheric pressure as well as any pressure created by filling and emptying the tank. All U-vents shall be equipped with mesh insect screening. All U-vents shall be constructed of PVC SCH 80.
- E. Where indicated, tanks shall be provided with ancillary mechanical fittings and accessories. Tanks shall be marked to identify the manufacturer; date of manufacture and serial numbers must be permanently embossed into the tank.
- F. Type: Above ground, upright, cylindrical, flat bottom, capable of containing chemicals at atmospheric pressure and standard delivery temperatures.
- G. Construction:

- 1. Mechanical Properties of crosslinked polyethylene (XLPE), for all storage and day tanks, except the Sodium Hypochlorite storage and day tanks.

Property	ASTM	Value
Density (resin),	D1505	0.938-0946 g/cc
Tensile Strength, Ultimate psi, 2-inch/min	D638	2,830-3000 psi
Elongation at Break , % (2-inch/min)	D638	700-800%
ESCR (100% Igepal, Cond A, F50)	D1693	>1000 hours
Vicat Softening Degrees F Temp	D1525	250 deg F
Flexural Modulus	D790	87,000-110,000 psi

- H. All polyethylene resin material shall contain a minimum of a U.V. 8 stabilizer as compounded by the resin manufacturer. Pigments shall not exceed 0.25% (dry blended) of the total weight.
- I. The minimum required wall thickness for a given hoop stress is to be calculated in accordance with ASTM D1998. Tanks shall be designed using a hoop stress no greater than 600 psi. In NO cases shall the tank thickness be less than design requirements per ASTM D1998.
 - 1. The wall thickness of any cylindrical portion at any fluid level shall be determined by the following equation.

$$T = P \times OD / 2SD = 0.433 \times SG \times H \times OD / 2SD$$

where,

T= wall thickness

SD= hydrostatic design stress, PSI

P= pressure (.433 x SG x H), PSI

H= fluid head, ft

SG= specific gravity, g/cm³

OD= outside diameter, in.

- a. The minimum wall thickness shall be sufficient to support its own weight in an upright position without external support but shall not be less than 0.187" thick.
 - b. The hydrostatic design stress shall be determined by multiplying the hydrostatic design basis, determined by ASTM D2837 using rotationally molded samples, with a service factor selected for the application. The hydrostatic design stress is 600 psi at 73 deg F.
2. The minimum required wall thickness for the cylinder straight shell must be sufficient to support its own weight in an upright position without any external support.
 3. The top head shall be integrally molded with the cylinder shell. The minimum thickness of the top head shall be equal to the thickness of the straight wall.
 4. The bottom head shall be integrally molded with the cylindrical wall. Knuckle radius shall be:

Tank Diameter, ft	Min. Knuckle Radius, inch
Less than or equal to 6	1
Greater than 6	1-1/2

- J. Tanks with 2000 or more gallons of capacity shall have a minimum of 3 lifting lugs integrally molded into the top head. The lifting lugs shall be designed to allow erection of an empty tank.
- K. All dimensions shall be taken with the tank in the vertical position, unfilled. Tank dimensions shall represent exterior measurements.
- L. The top head must be integrally molded with the cylinder shell. The minimum thickness of the top head shall be equal to the top of the straight wall. The top head of tanks with 2000 or more gallons capacity shall be designed to provide a minimum of 1300 square inches of flat area for fitting locations. Each Bulk Storage Tank shall be equipped with following accessories:
 1. 24-inch top access round air-tight manway with gasketed cover.

2. Provide 2-inch flanged ball dome bulkhead fitting for fill line connection
3. Provide 6-inch flanged ball dome for vent line connection
4. Provide 4-inch NPT vertical swivel-type bulkhead for level probe
5. Provide 4-inch flanged fitting for overflow pipe equipped with pipe support brackets on side of tank.
6. Provide 4-inch flanged outlet on the sidewall at the bottom of the tank for tank drain/pump suction connection.
7. Provide FRP ladder located between the manway access and the level probe.
8. Identification signs.

M. Material of Construction:

1. Fittings: All fittings shall be bolted double flange with 150 lb. flanges in accordance with ANSI/ASTM B 16.5 standards.
2. Gaskets shall be min of 1/4-inch thickness, constructed of 40-50 EPDM or 60-70 Viton material based on the chemical compound stored, refer to the table below.
3. Bolts shall be encapsulated in the same material used in the tank construction. The encapsulation shall prevent metal exposure to the liquid in the tank and prevent bolt rotation during installation. The encapsulation shall fully cover the bolt head and a minimum of 1/4-inch of the threads closest to the bolt head. Each encapsulated bolt shall have a gasket to provide a bolt-sealing surface against the inner flange. Bolts shall be constructed of the materials as provided in the table below.

Chemical	Concentration, S.G.	Resin	Design	Fitting Material	Gasket Material	Bolt Material
Aluminum Chlorohydrate	38%, 1.3-1.35	XLPE	1.9/600	PVC SCH 80	EPDM	316 SS
Sodium Bisulfite (NaHSO ₃)	38%, 1.32	XLPE	1.9/600	PVC SCH 80 / PP	EPDM	Titanium

2.02 TANK SYSTEM ACCESSORIES:

- A. Restraints:** The tanks shall be provided with necessary structural support members, including tank restraints. Design shall conform to the most recent edition of the IBC code for seismic winds and loads, as required in the architectural and structural code classifications.
1. Conform to the seismic requirements indicated on the structural drawings.

2. Provide all equipment bases, anchorage, supports, and foundation designed in accordance with the seismic requirements indicated.
- B. Fittings: The bolted double flange fittings shall be constructed with 2ea. 150 lb. flange gaskets in accordance with ANSI/ASME B-16.5. The flanges shall be constructed of PVC type 1, Grade I.
 - C. All tank fitting attachments shall be equipped with flexible couplers. Tank piping flexible couplers shall be designed to allow 4% design movement and shall be attached as close as possible to the tank to reduce stress. The flexible connection shall have 150 lb. flange connection to allow for attachment to the tank and the piping system. The flexible connection shall be manufactured of the same material as the tank or a compatible material approved by the Engineer.
 - D. Tank drain: The Storage Tank drain fitting shall utilize molded outlet and shall be an integral part of the tank, providing completed drainage of liquid through the sidewall of a flat bottom container without the use of special support structure or concrete pad. The standard outlet provided shall be a PVC socket which allows solvent weld PVC at the tank pad level.
 - E. Reverse Float Level Gage: Constructed of flexible clear PE or PVC tubing to allow for tank contraction and expansion due to loading and temperature changes. The level gage shall be connected to the top of the tank (no sidewall penetration). Internal float weighted for specific chemical. Polypropylene rope. Calibration tape for volume in gallons.
 - F. Connection for Ultrasonic or Radar Level Indicator.
 - G. Bolted Sealed Top Manway: The sealed manway shall be constructed of polyethylene material. The bolts shall be polypropylene or other specified material. The gaskets shall be closed cell, crosslinked polyethylene foam and Viton o-rings to seal the bolts.
 - H. Fill Pipe: All down pipes and fill pipes shall be supported at 5 ft. maximum intervals with support structures. Standard support structure design shall utilize bulkhead fitting tank attachments or welded attachments on Type II tanks.
 1. Provide anti-siphon vent on all fill pipes.
 - I. Ladder: Ladders shall be constructed of FRP. All ladders shall be designed to meet applicable OSHA standards. Reference: OSHA 2206; 1910.27; fixed ladders. Ladders must be mounted to the tank to allow for tank expansion and contraction due to temperature and loading changes. All top ladder mounts shall be connected to integrally molded in attachment lugs that allow for tank movement due to temperature and loading changes.
 - J. Overflow pipe and vent pipes.

2.03 POLYETHYLENE TANK SCHEDULE:

A. General requirements for all tanks.

1. All fittings shall be flanged, sizes and locations as shown on the drawings.
2. Provide numbered calibrations for visual inspection of tank level.
3. Provide a minimum of 6-inch freeboard.
4. The dimensions listed in the schedule below shall be taken as approximate tank volumes and dimensions, and alternate dimensions may be approvable for an equal or greater tank storage volume. However, tank manufacturer and contractor must verify that an alternate size tank will fit in the designated space. Alternate size bulk tanks must consider available overhead clearances, containment area widths, and necessary clearances from other equipment. Alternate size day tanks must correspond to sizes of scales being furnished.

B. Aluminum Chlorohydrate

1. Two bulk tanks: 3,000 gallon tank (sealed); 7'-1" diameter x 12' tall.

C. Sodium Bisulfite

1. One bulk tank: 4,925 gallon tank (sealed): 9'-0" diameter x 12'-3" tall.

D. The General Contractor shall provide all bolts, anchor bolts, nuts, washers, and supports as required for all the tanks specified in this Section, and in accordance with the requirements of the manufacturers of the tanks. All bolts, anchor bolts, washers, hold down lugs, and supports required in connection with the tanks provided under the Section shall be of Type 316 stainless steel, if not otherwise noted.

2.04 SAFETY SIGNS:

- ### A.
- Each tank shall be clearly marked with the name of the chemical stored, printed in large block letters and mounted directly adjacent to the tank outlet and tank inlet. Each entry manway shall be provided with a sign ("DANGER—CONFINED SPACE—HAZARDOUS ATMOSPHERE").

PART 3 - EXECUTION

3.01 INSTALLATION

- ### A.
- All tanks shall be installed on level concrete pads per the manufacturer's instructions. All pipes and equipment connecting to the tanks shall be firmly supported to avoid stresses on the tank.

- B. Prepare tank pads to support total weight of tank and contents. Cutouts are required in concrete pads for full drain nozzles. Check with fabricator for cut out dimensions. Cut outs in pads shall be grouted under full drain after installation.
- C. Tanks shall be installed according to fabricator's recommendations. Fabricator's unloading and handling instructions shall accompany the tank during shipping. Bottoms and full drains shall be fully supported.
- D. During installation of the tanks, care shall be taken to prevent contamination of the tank interior. Nozzles and manways shall be covered except when connecting pipes or other equipment.
- E. Closed top tanks are considered a confined space. A confined space entry permit shall be obtained, and all Contractor confined space entry procedures shall be followed.
- F. Entry into the tanks shall be minimized. Entry into a tank shall require written permission from the Contractor. When working in the tanks, care shall be taken not to damage the interior surfaces. The floor shall be covered with plastic sheeting or similar protection. Any workers entering a tank shall wear soft-soled shoes and wear clean room shoe covers. If ladders are placed in the tank, protection shall be provided between the tank surface and the ladder.
- G. Installation certificate: Contractor shall provide shall certify that the tank system has been installed according to the tank manufacturer's Guidelines for Use and Installation.

3.02 WORKMANSHIP:

- A. The finished tanks shall be free of visual defects such as foreign inclusions air bubbles, pinholes, pimples, crazing, cracking, and delaminations that will impair the serviceability of the vessel.
- B. All cut edges where openings are cut into the tanks shall be trimmed smooth.

3.03 FIELD INSPECTION:

- A. Perform a 72-hour hydro test for each tank to check for leaks on field erected tanks. Hydrotest shall be performed in conjunction with the chemical feed system hydrotest. Following the hydrotest, the tanks shall be drained and dried. Clean, dechlorinated water shall be used for the hydrotest.

3.04 MANUFACTURER'S SERVICES:

- A. Conform to the requirements of Specification Section 01 43 00.
- B. The EQUIPMENT SUPPLIER shall provide a factory trained representative to be retained for a period of not less than 16 hours (up to 2 trips) to inspect equipment installation, piping and wiring to ensure proper installation of each component in accordance with approved submittals.

- C. Startup services and training of Owner's personnel shall be at such times as requested by the Owner.
- D. Additional time required to perform these services shall be at no additional cost to the Owner. The Owner shall be credited for the unused portion of startup services.

3.05 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 44 40 40

EMERGENCY DRY TYPE CHLORINE SCRUBBER SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test emergency dry type chlorine scrubber system equipment and appurtenances, as indicated and in compliance with Contract Documents.
- B. Provide emergency dry type chlorine scrubber system complete. And before acceptance make the system fully operational and ready for use by the Owner.
- C. Mechanical testing of system to be conducted by the Contractor.
- D. Dry media samples and chlorine gas for testing to be conducted by the Supplier. Results of removal of chlorine gas using dry media to be reported to Owner prior to system installation.
- E. Emergency dry type chlorine system to meet:
 - 1. The Utah Department of Environmental Quality, "R309-200. Monitoring and Water Quality: Drinking Water Standards" (Latest Revisions).
 - 2. The Utah Department of Environmental Quality, "R309-520. Disinfection" (Latest Revisions).
 - 3. The Utah Department of Environmental Quality, "R309-520. Facility Design and Operation: Disinfection" (Latest Revisions).

1.02 REFERENCES:

- A. American Gear Manufacturer's Association (AGMA).
- B. Anti-Friction Bearings Manufacturer's Association (AFBMA).
- C. Air Moving and Conditional Association (AMCA):
 - 1. Standard 210-74: Laboratory Methods of Testing Fans for Rating Purposes
- D. American Society for Testing and Materials International (ASTM)
 - 1. C581-83: Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures, intended for Liquid Service.
 - 2. D638-84: Test Method for Tensile Properties of Plastics.

3. D790-84a: Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials.
 4. D2563-70 (1977): Recommended Practice for Classifying Visual Defect in Glass-Reinforced Plastic Laminate Parts.
 5. D2583-81: Test for Indentation Hardness of Rigid Plastics by means of Barcol Impresser.
 6. D3299-8: Filament Wound Glass Fiber Reinforced Polyester Chemical-Resistant Tanks
 7. D4097: Contact-Molded Glass Fiber Reinforced Thermoset Corrosion-Resistant Tanks
- E. American Society of Mechanical Engineers (ASME):
1. PTC 10 (R2014): Performance Test Code on Compressors and Exhausters
- F. American National Standards Institute (ANSI).
- G. National Bureau of Standards (NBS):
1. PS 15-69: Custom Contact Molded Reinforced Polyester Chemical-Resistant Process Equipment
- H. American Welding Society (AWS).
- I. Institute of Electrical and Electronics Engineers (IEEE).
- J. National Electric Code (NEC).
- K. National Electrical Manufacturers Association (NEMA):
2. ICS 1: Industrial Control and Systems General Requirements
- L. Steel Structures Painting Council (SSPC).
- M. American Iron and Steel Institute (AISI).
- N. Hydraulic Institute (HI).
- O. The Chlorine Institute, Inc.
1. Chlorine Manual.
- S. Uniform Fire Code:
1. Article 80

- U. Standard Fire Code.
 - V. Building Officials and Code Administration of America (BOCA).
 - W. International Building Code (IBC).
- 1.03 SUBMITTALS:
- A. Submit the following shop drawings in accordance with Section 01 33 00:
 - 1. Prior to initial submittal, arrange conference in Engineer's office with Engineering Representatives of equipment vendor who are familiar with specification to discuss overall job concept.
 - 2. When the Contractor proposes equipment which requires an arrangement differing from that indicated on the drawings or specified, prepare and submit for review detailed structural, mechanical, and electrical drawings and equipment lists, utilities consumption schedule and operating instructions, showing necessary changes and embodying special features of the equipment he proposes to furnish. Make changes, if accepted at no additional cost to Owner.
 - 3. Certified shop and working drawings which include plan, elevation, and sectional views, materials of construction, ductwork, anchor bolt details, electrical, and controls.
 - 4. Certified setting plans, with tolerances, for anchor bolts.
 - 5. Operating and maintenance instructions and parts lists.
 - 6. Shop drawings details for accessory items.
 - 7. Number and identify components to correspond with terminology on drawings. Use these numbers on all submittal sheets and shop drawings.
 - B. Submit the following product data within 60 calendar days after the Contractor has received the Owner's Notice to Proceed:
 - 1. Materials list of items proposed to be provided under this section.
 - 2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
 - 3. Certified design calculations substantiating design criteria.
 - 4. Control details and wiring diagrams.
 - 5. Equipment performance data, motor data, curves, etc.

- C. Provide complete design calculations for the emergency dry type chlorine scrubber system to confirm the following:
1. The system design calculations must demonstrate a minimum overall system removal efficiency of 99.99%.
 2. The pressure in the chlorine storage room must never exceed ambient atmospheric pressure from the beginning of the design leak event to the time the scrubber system shuts off.
 3. The system shall be capable of withstanding the imposed seismic and wind loads in accordance with Section 01 41 20. Certified design calculations shall be stamped by a registered professional engineer. Calculations shall include, but not be limited to, the following:
 - a. Dead loads
 - b. Live loads
 - c. Seismic loading per IBC code
 - d. Anchor lug attachment to the shell
 - e. Wind loads
 4. The system contains a minimum amount of dry chemical media required to scrub the total amount of chlorine during the leak event. Calculations shall include ventilation rate, system pressure, chlorine flow and weight from the beginning to the end of the scrub cycle.
 5. The percentage decrease in the dry chemical media during a test cycle of 5 minutes every month assuming no chlorine is absorbed.
 6. The exhaust fans are each capable of handling the minimum required air flow from the chlorine storage room including the resistance of all ductwork, fittings, and system components.
- D. Recommendations for short and long term use.
1. Sales bulletins or other general publications are not acceptable as submittals for review except where necessary to provide supplemental technical data.
- E. Provide Operation and Maintenance manuals in accordance with Section 01 78 23. Manuals may be in one or more volumes but shall include, as a minimum, complete sections covering all equipment specified in this section and spare parts lists.
- F. ISO 9001 certification or other quality control manual demonstrating a complete system for quality management.

- G. Emergency dry type chlorine scrubber system equipment manufacturer must be capable of providing a list of customers using at least five (5) similar system for at least ten (10) years.
- H. Material Certification:
 - 1. Provide certification from the manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of three (3) years. Provide proposed materials at no additional cost to the Owner.
 - 2. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
- I. Certified results of factory tests.
- J. Provide Affidavit from the system supplier stating that the complete emergency dry type chlorine scrubber system has been properly installed, tested, and is ready for full-time operation.
- K. A copy of the contract mechanical process, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required".
 - 1. Failure to include all drawings applicable to the equipment specified in this section will result in rejection of the entire submittal with no further review.
- L. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations and clarifications from the specified requirements.
 - 1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in rejection of the entire submittal with no further review and consideration.

1.04 SPARE PARTS:

- A. Provide in accordance with Section 01 61 00 and as specified herein.
- B. Furnish spare parts, identical and interchangeable with similar parts installed in work:
 - 1. Two sets of belts for the fan/motor assembly per fan.
- C. Package in one container all spare parts and clearly identify on the outside what the unit is for.
 - 1. Seal tightly and protect for long term storage.
 - 2. Deliver to the Engineer for transmittal to the Owner.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00
- B. Do work required by and in accordance with applicable State and local codes; arrange for permits, inspections and tests required by these codes. Provide systems and items of equipment that conform to applicable safety standards including those for safety of personnel.
- C. Furnish the emergency dry type chlorine scrubber system by one equipment supplier who shall provide all the equipment and appurtenances specified in this section, regardless of manufacturer, and be responsible to the Contractor for the complete and satisfactory operation of the entire system.
 - 1. Substitutions of functions specified will not be acceptable.
 - 2. Experience:
 - a. Certify to no less than ten identical type installations presently in service for one or more years.
 - b. A minimum of ten years of experience in the design, fabrication, and testing of systems that are efficient in converting chlorine gas to non-toxic solids with less than 5 ppb at discharge.
 - c. Certified to ISO-9001 standards.
 - 3. Evidence of manufacturing capability including description of facilities, the number and qualifications of personnel, and quality control practices. The alternate equipment supplier shall identify major outside fabricators for the purpose of determining experience.
 - 4. Evidence of technical capability to design and check the alternate system fully, including modifications required to building and other systems.

5. Evidence of full-scale testing of the scrubber designed by an independent testing laboratory, as outlined in Paragraph 3.02.
 6. A complete listing of changes which will be required in the contract plans and specifications to accommodate the alternate equipment.
- D. Provide components to manufacturer's standard for service specified and indicated unless otherwise required.
- E. Provide equipment of manufacturers' latest and proven design. Unit to be a standard cataloged product and modified as specified and indicated.
- F. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.
- G. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
1. Service Technician must have a minimum of five (5) years of experience, all within the last seven (7) years, on the type and size of equipment.
 2. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 3. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping, electrical and miscellaneous utility connection:
 - a. 1 person-day.
 4. Startup, Commissioning, and Testing: Calibrate, check alignment and perform a functional test of mechanical equipment. Perform equipment startups and field performance tests to include all items specified. Failure of any testing shall be corrected without additional expense to the Owner. At the conclusion of commissioning and testing, the manufacturer shall Certify installation and operation.
 - a. 2 person-days.
 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.
 - a. 1 person-day.
 6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.

7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- A. Systems:

1. Provide emergency dry type chlorine scrubber system equipment for the following:

Tag No.	Application Point	Capacity (cfm)
SK-0301-16	Emergency Chlorine Dry Scrubber	Minimum 5,000

- B. DESIGN PARAMETERS

1. Chlorine Treatment Capacity: 4,700 lbs (2, 1-ton containers)
2. Chlorine Gas Release Rate: 437 lbs/min (2,380 scfm)
3. Treated Air Capacity: Minimum 5,000 cfm
 - a. Or better as required by US Uniform Fire Code with local amendments (Article 80, Hazardous Materials), Uniform Building Code, the latest NIOSH guidelines, and all rules/regulations of authorities having jurisdiction over the work specified herein.
4. Maximum Chlorine Concentration in Treated Air: 5 ppb
5. Max Chlorine Gas Temperature: 160°F
6. Max/Min Scrubber Tank Temperature: 200°F / -40°F
7. Provide sufficient draft to overcome the resistance of ductwork, fittings, dampers, and silencers to maintain a negative pressure in the room to prevent atmosphere leakage of vapor.

- a. Standard Pressure up to scrubber inlet (for duct losses): 1 1/2-inch to 2-Inch W.C.

2.02 MANUFACTURERS:

- A. De Nora Water Technologies, LLC.
- B. Purafil Filtration Group ®.
- C. PureAir Filtration
- D. Engineer-Approved Equivalent.
- E. The basis of design for this system is De Nora Water Technologies, LCC. Alternative manufactures listed above are acceptable, but any deviations from the De Nora Design, such as fan horsepower requirements, air duct sizes, scrubber dimensions, etc., must be included in the cost of the bid.

2.03 DRY MEDIA HOLDING TANK

- A. Vertical, 120-Inch diameter, fabricated filament wound Fiberglass Reinforced Plastic (FRP)
 - 1. Acceptable Main Layer Resin Manufacturers (Premium Vinyl Ester):
 - a. Ashland, Trade Name: Hetron 922
 - b. INEOS, Trade Name: Derakane 411-400
 - c. Reichold, Trade Name: Atlac 580
 - d. Dow, Trade Name: Kerakane 411
 - e. Interplastic, Trade name: VE8300
 - f. Other premium resins may be considered if a certified letter of suitability for the service is presented to the Engineer.
 - 2. Exterior Resin Layer
 - a. An exterior resin layer applied shall be applied using the same premium resin used as the main layer with a methyl ethyl ketone peroxide (MEKP) cure.
 - 3. Interior Corrosion Barrier
 - a. An interior resin layer, 10 millimeters to 20 millimeters in thickness, shall be applied using the same premium resin used as the main layer.

- b. Layer shall be composed of reinforced non-continuous glass fiber strands applied in two plies of chopped strand mat equivalent to three ounces per foot.
 - (1) Acceptable Materials:
 - (a) Nexus Veil corrosion barrier
 - (b) Engineer-Approved Equal
 - (2) The inner layer shall not exceed 10% +/- 15% "C" glass by weight.
- 4. Filament wound laminates shall have an average glass concentration of 50% - 55% by weight.
- 5. Fabricate hand lay-up laminates when used on the vessels and equipment shall meet the physical properties in accordance with PS 15-69 product standard.
- 6. The tank shall be manufactured in accordance with ASTM D-3299 standard specifications for filament wound construction or for custom contact-molded construction in accordance with NBS PS 15-69 product standard and ASTM D-4097.
- 7. Tank resin shall be suitable for continuous exposure to a wet chlorine/air mixture with a maximum operating temperature of 200°F.
- 8. Barcol hardness shall confirm with the resin supplier's minimum value.
- B. All exterior FRP surfaces shall have a pigmented resin for UV protection.
- C. The tank shall be designed for the shut-off vacuum.
- D. Press molded or compression mold flange nozzles are acceptable up to and including 6-Inch nominal size.
- E. Reinforce all cut-walls as required by ASTM D-3299 and PS 15-69.
- F. Tank shall be completed with a side-mounted 1 1/2-Inch drain connection.
 - 1. Arrange drain connection as indicated on drawings
- G. The media bed support system shall be constructed of materials resistant to the service conditions specified for corrosion and exposure to wet chlorine in air at 200°F for up to 10 hours.
- H. Media shall be supported by a 1-Inch thick FRP grating with 1-Inch by 4-Inch openings.
- I. Grating shall be supported along its circumference by a support shelf integrally bonded to the tank walls.

- J. The span of the grating shall be supported by three (3) uniformly spaced rectangular beams, each with a 4-Inch by 6-Inch cross section.
1. Each beam will be midway supported by a 4-Inch by 6-Inch vertical pillar from the tank bottom.
 - a. Beams shall be integrally bonded to the tank sidewall for maximum support.
- K. Tank Connections:
1. One (1) 30-Inch diameter flanged nozzle covered access opening shall be provided for media addition.
 2. One (1) 30-Inch diameter flanged side covered access opening shall be provided for media removal.
 3. One (1) 20-Inch diameter flanged nozzle, 4-Inches long shall be provided for gas inlet.
 4. One (1) 18-Inch diameter flanged side, 4-Inches long shall be provided for treated exhaust air outlet.
 5. Five (5) 1 1/2-Inch diameter side-mounted, sample ports with PVC ball valves.
 6. One (1) 2-Inch diameter flanged side shall be provided as a drain for treated scrubber effluent waste drainage.
 7. Six (6) 1-Inch tie-down/support lugs
 - a. The tie down/support lugs shall be designed to be able to anchor the tower and contents against seismic and wind loading requirements in accordance with Section 01 41 20.
 8. Three (3) 1-Inch lifting lugs
 - a. The lifting lugs should be permanently attached and suitable for lifting and transporting the empty tank without structural damage.
 9. All connections shall be fabricated of the same material as the tank wall and shall have the same inner corrosion barrier as the tank wall.
 - a. Connections shall be as indicated on drawings.
 10. The flanges shall be connected to ductwork and lids using 18/8 stainless steel flange hardware.
- L. The dry media holding tank should not be lifted with the media packed inside the tank.

- M. The Contractor shall place the dry media in the tank after the tank is installed at the job-site.
- N. All gas connections shall conform to Table 2 of PS 15-69.
- O. FRP Ladder
 - 1. An OSHA-rated FRP access ladder with cage system shall be permanently clipped to the tank top.
 - 2. FRP ladder to be in accordance with Section 06 60 10.
- P. The tank top shall have a non-skid surface and toe kick.
- Q. The tank top shall include a clipped-up FRP safety handrail along the entire rim of the tank top.
 - 1. FRP handrail to be in accordance with Section 06 60 10.
- R. Neoprene Pad: A 1/4-inch thick, 60 durometer neoprene rubber sheet shall be placed underneath the dry media holding tank.

2.04 DRY MEDIA

- A. Chemically impregnated activated alumina (alumina oxide) media
 - 1. Quantity: Media to treat 4,700 lbs of chlorine gas.
 - 2. MANUFACTURERS:
 - a. De Nora Water Technologies, LLC.
 - b. Purafil Filtration Group ®
 - c. PureAir Filtration
 - 3. Media shall have a powdered alumina oxide (alumina) substrate and other powdered materials suitably impregnated with chemicals capable of removing chlorine throughout the entire media bed, be spherical in shape (pellets), porous, non-flammable, and will not support combustion.
 - a. Impregnates during media formation shall be uniformly distributed throughout the pellet volume.
 - 4. Media with carbon in the substrate will not be accepted.
 - 5. CHARACTERISTICS:

- a. Average Crush Strength: 17 lbs on a representative sized media bed; 35% minimum – 70% maximum
 - (1) Average Density: 45 lbs/ft³ to 50 lbs/ft³
 - b. Average Media Diameter: 1/8-Inch to 3/16-Inch
 - c. Media will not dissociate in water
 - d. Media contains no activated carbon
 - e. Media shall be UL Fire Class 1 Non-flammable
 - f. Media shall neutralize 99.99% chlorine gas at the maximum chlorine inlet gas rate by chemically reacting with the chlorine to produce solid products within the media.
 - g. Moisture Content: 35% maximum
 - h. Average Abrasion: 4.5 maximum
6. The pressure drop of air at 70°F when flowing through 12-Inch deep packed media bed shall not exceed:

Superficial Velocity (fpm)	Pressure Drop (inch W.C.)
50	0.45
100	1.85

7. Media when subjected to auto ignition test method ASTM D-3466-76 (1998) shall demonstrate auto ignition temperature of no less than 300°C.

B. Support Media

- 1. Media support gravel shall be provided to support the activated alumina media.

2.05 EQUIPMENT

A. Exhaust Scrubber Fans

- 1. FAN DATA:

Tag No.	Operation	Minimum Capacity (cfm)
BLR-0301-17	LEAD	5,000

BLR-0301-18	LAG	5,000
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2. TYPE:
 - a. Centrifugal type, FRP construction
 - b. Backward inclined or radial blade
 - c. Fan shall have a AMCA seal.
3. MANUFACTURER:
 - a. New York Blower
 - b. Hartzell
 - c. Engineer-Approved Equal
4. Electrical Requirements:
 - a. Power: 25 HP
 - b. Voltage: 480 VAC, 3 phase
 - c. Frequency: 60 Hz
 - d. Motor Type: Totally Enclosed Fan-Cooled (TEFC) high efficiency motor
 - e. Motor Speed: 1800 rpm
 - f. Service Factor: 1.15
5. Fan wheel shall be statically and dynamically balanced.
6. Fiberglass construction shall conform to PS 15-69 product standards.
 - a. Fan resin shall be suitable for exposure to the specific service conditions.
7. Fan housing shall be constructed of fiberglass and reinforced with rigid bracing to increase structural integrity.
 - a. Bearing support brackets shall be positioned to directly oppose belt tension forces.
8. Fan housing shall be a curved scroll design with a 1-Inch NPT drain connection at the bottom of the fan scroll.

9. Fan outlets shall have flanged connections.
10. The fan shaft shall be epoxy coated steel.
11. The fan shall have self-aligning grease-packed bearings, with neoprene shaft seals and OSHA approved weatherproof motor/drive cover.
12. Contractor shall include a duct transition piece with flex connector between blower and connecting intake FRP ductwork.
 - a. The flexible connector shall be resistant to UV degradation.
13. Contractor to provide FRP ductwork from exhaust fan to stack hood including 316L stainless steel straps.

B. Control Panel

1. NEMA 4X, 316 Stainless Steel control panel
 - a. The control panel shall have a transformer
 - (1) 480 / 120 VAC, 300 VA
 - b. The control panel shall have a hinged front door
 - c. The control panel shall have exhaust fan motor starters
 - d. The control panel shall have wall mounting.
 - e. The control panel shall have alarm contacts
 - (1) Scrubber Running
 - (2) Blower fault/system alarm
 - f. The control panel shall have relay controls
2. Minimum requirements:
 - a. A power ON light
 - b. Fan running lights
 - c. Chlorine Leak Light (connected to chlorine gas detector)
 - d. Cabinet disconnect switch
 - e. Scrubber fan ON indicating light

- f. Fan Lead/Lag Selector switch
 - g. Fan HAND-OFF-AUTO selector switches with push button
 - h. Pushbutton for RESET
 - i. 20% spare terminals
 - j. Power: 480 VAC, 3 phase, 60 Hz, 40 amps
3. Include the following I/O in the form of dry contacts:
- a. Input: Chlorine detector alarm from chlorine gas storage room (starts LEAD fan).
 - b. Input: Differential pressure switch activated (below low-level set point shuts off LEAD fan and turns on LAG fan).
 - c. Input: Chlorine detector alarm from emergency dry scrubber (stops LEAD/LAG fan)
 - d. Input: RESET push button shuts off LEAD/LAG fan.
 - e. Output: Stop ventilation fan(s) in chlorine storage room.
 - f. Output: Control panel in AUTO (provide for remote indication).
 - g. Output: Scrubber fan running (provide for remote indication).
 - h. Output: Scrubber fail to run on command (provide for remote indication).
 - i. Output: Scrubber shut down by alarm (provide for remote indication).
4. Labeling:
- a. Early identifying label all panel devices.
 - b. Provide engraved white laminated labels with black lettering.
 - c. Attach with stainless steel screws.
5. Motor Starters:
- a. Provide for each motor a NEMA rated magnetic motor starter.
 - (1) Manufacturer:
 - (a) Allen Bradley, Square D (Class 8606)

- (b) Engineer-Approved Equal
 - (2) Equip with undervoltage release and overload protection on all three phases.
 - (3) Furnish motor starter contacts that can be easily replaced without removing the motor's starter from its mounted position.
 - (4) Use manual reset overload relays and do not provide means for converting to automatic reset.
 - b. Provide open frame, reduced voltage, non-reversing, autotransformer, closed transition type.
6. Components:
- a. Provide thermal magnetic air circuit breaking having a minimum symmetrical RMS interrupting rating of 14,00 amperes at 480V.
 - (1) Provide a pad lockable operating mechanism on each motor circuit breaker.
 - (2) Type:
 - (a) Square D
 - (b) General Electric
 - (c) Engineer-Approved Equal
 - b. Hand-Off-Auto Switches:
 - (1) Provide UL rated, heavy duty, 600 VAC, NEMA 4X, oil-tight switches.
 - (a) Manufacturer:
 - Allen Bradley Series 800H
 - Square D Class 9001 SK
 - Engineer-Approved Equal
 - (2) "Hand" position not to override motor overload shutdown.
 - c. Provide lighting arrestor
 - (1) Type:

- (a) Delta Type “LA”
 - (b) Engineer Approved-Equal
 - d. Control Relays:
 - (1) Provide heavy-duty industrial grade plug-in relays
 - (a) Type:
 - Allen Bradley, Bulletin 700, Type H
 - Square D, Class 8501, Type K
 - (2) Provide appropriate sockets for din rail mounting.
- 7. Indicator Lamps:
 - a. Type:
 - (1) Allen Bradley Series 800H
 - (2) Square D Class 9001 SK
 - (3) Engineer-Approved Equal
- 8. Control Relays:
 - a. Provide heavy-duty industrial grade relays.
 - (1) Type:
 - (a) Allen Bradley, Bulletin 700, Type H
 - (b) Square D, Class 8501, Type K with silver cadmium oxide contacts and LED indicator.
- 9. Electrical Schematic:
 - a. Provide a number indexed laminated electrical schematic diagram of the panel controls including terminal board connections.
 - b. Permanently mount on the inside of the enclosure door.
- 10. Attachment screws shall all be stainless steel.
- 11. Wiring:
 - a. Unit to be completely factory wired except for power supply.

- (1) Comply with applicable standards of National Electric Code.
 - (2) Color code and number as indicated on factory wiring diagram.
 - (3) Control wire to be MTW 90EC #14 AWG.
 - b. Electrically ground all components to a common ground screw.
 - c. Provide printed wire markers for each wire termination point.
 - d. Neatly route all internal wiring in enclosure:
 - (1) Plastic Wireway with cover
 - (2) Panduit
 - (3) Engineer-Approved Equal
 - e. Provide continuous internal wiring between termination points with no splices.
 - f. Protect looped wiring between control panel interior and front panel from abrasion by using plastic spiral wrap or braided polyester sheath.
 - g. Provide forked spade type wire lugs where used.
12. Control Panel Functional Operation:
- a. HAND-OFF-AUTO selector switch settings (per fan)
 - b. In AUTO mode, the LEAD fan will start by chlorine gas detector signals (two total). The LEAD fan will run until the RESET button is pushed or is shut off by the differential pressure switch activating. The LAG fan will run until the RESET button is pushed if activated by the differential pressure switch.
 - c. In HAND mode, the fan will run while HAND position remains selected.
 - d. In OFF mode, the fan is disabled.
13. Upon alarm signal from the chlorine gas detectors (from remote chlorine detector dry contacts):
- a. Illuminate chlorine leak lamp.
 - b. Start LEAD fan immediately.
 - c. Illuminate fan running lamp.

14. The LEAD fan will run until the control panel RESET push button is depressed and the chlorine detector alarm is cleared or if deactivated by the differential pressure switch.
15. The LAG fan will run after the differential switch is activated and until the control panel RESET push button is depressed and the chlorine detector alarm is cleared.
16. Upon RESET, if the chlorine detector alarm is cleared, the fan will stop. With the HAND-OFF-AUTO selector switch remaining in AUTO position the fan will remain in a ready mode and will restart automatically upon another chlorine detector alarm.
17. IF the scrubber is running, in HAND or AUTO, stop the operation of the ventilation fan(s).
18. Provide signal to plant SCADA to indicate scrubber run status.

2.06 DUCTWORK:

A. General:

1. Refer in accordance with Section 23 31 16.
2. Ductwork passing through walls or floors of chlorine storage area caulked gas tight as specified for plumbing work.
3. The Contractor shall supply and arrange the FRP suction and discharge ductwork at the points of application as indicated on drawings. Sizes and capacities not specified herein are indicated on drawings.

B. Chlorine gas and treated exhaust air:

1. No Loss Dilution Exhaust Stack
 - a. FRP construction, flanged
 - b. The exhaust stack shall be the “No Loss” induced dilution air design.
 - c. The stack shall include a 300 series stainless steel bird screen and rain cap/hood
 - (1) The bird screen shall not cause excessive head loss to the fan.
 - d. Size: 20-inch
 - (1) The plain end of the inner duct section shall be covered with a 1 1/2-Inch square bird screen.

1. 1 1/2-Inch SCH 40 PVC

2. 1-Inch SCH 40 PVC

2.09 PVC VALVES

A. Media Sample Ports:

1. 1 1/2-Inch PVC ball valves.

2.10 DAMPER VALVES

A. Treated exhaust air:

1. 20-Inch round control type FRP damper.

B. MANUFACTURER:

1. Ruskin.

2. Engineer-Approved Equal.

2.11 DUCTWORK FITTINGS:

A. Refer to Section 23 31 16.

B. Chlorine gas:

1. Material to be the same as the dry media scrubber.

2.12 FITTINGS:

A. Chlorine gas and treated exhaust air:

1. Refer to Section 23 31 16.

2. .

3. 1/2-Inch FRP flanged joint fittings.

B. Treated scrubber and fan effluent drainage waste:

1. 1 1/2-Inch SCH 40 PVC fittings.

2. 1-Inch SCH 40 PVC fittings.

2.13 DIFFERENTIAL PRESSURE GAGE AND SWITCH:

A. Differential pressure gage and switch shall be in accordance with Section 40 73 00.

- B. The differential pressure switch shall activate if the differential pressure falls below 10-inch W.C.
- C. The differential pressure gage and switch shall be mounted on the dry media tank per guidance of tank manufacturer.
- D. Route associated tubing to measure the pressure differential across the media bed.

2.14 RESIDUAL CHLORINE GAS DETECTOR AND TRANSMITTER

- A. Schedule: AE 0301-16 / AIT 0301-16.
- B. Type: Chlorine gas monitor and transmitter.
 - 1. Power: 5 W, 30 VDC
 - 2. SPDT contacts rated at 220VAC, 5 A.
 - 3. Signal output at 4 mA to 20 mA.
- C. Solid state type consisting of attached sensing unit (probe) and electronic control and transmitter unit (NEMA 4X housing).
- D. Mount sensor with sensing probe protruding into top FRP duct and sensor and transmitter remaining outside of duct as shown in the engineer drawings and per manufacturer's installation instructions for ductwork mounting.
- E. Sensor will detect up to 5 PPM (by volume of air) with 0.1 PPM resolution. Two additional sets of relay contacts (unpowered) to permit operation of external alarms and other equipment
 - 1. The alarm setpoint shall be greater than 0 PPM (by volume of air).
- F. Upon detection of gas at the alarm setpoint, control unit to send signal to shut off emergency dry gas scrubber.
- G. MANUFACTURERS:
 - 1. MSA Safety
 - 2. Approved-Equal

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install all emergency dry type chlorine scrubber system and connecting ductwork in accordance with manufacturer's instructions and as indicated.

- B. Anchor with 316 stainless steel hardware.
- C. Block and shim tank and fans as necessary to place at proper elevation plumb and level.
- D. Grout in place using non-shrink grout in accordance with Section 03 60 00.
- E. Snug and anchor bolt nuts as necessary.
- F. Erect system in the field in accordance with the manufacturer's installation drawings.
- G. Installation shall encompass the total emergency dry type chlorine scrubber system.
- H. Wiring to be in accordance with Section 26 05 20.
- I. Prior to testing and start-up, inspect the installation to verify the system is ready for complete testing and calibration of equipment.
- J. The dry media holding tank shall be mounted on a neoprene rubber mounting pad, 1/4-inch thick as specified by the tank vendor. Field route all piping connecting to the dry media holding tank with suitable deflection to accommodate the mounting pad.

3.02 FIELD QUALITY CONTROL: (CALIBRATION AND ACCEPTANCE TESTING)

- A. No form of energy shall be turned on to any part of the system prior to receipt by Engineer of certified statement of approval of installation from Contractor containing his supplier's authorization to energize system, except that supplier's servicemen may do so for purposes of check-out.
- B. After installation, and in presence of the Engineer, test system for a minimum of four (4) hours
- C. Perform an acceptance test to verify the satisfactory operation of the system and the design performance requirements of the specification. As a minimum, the test shall include but not be limited to the following:
 - 1. Conduct test in a representative section of the full-scale scrubber, at full scale media bed depth, and equivalent chlorine gas loads.
 - 2. The chlorine load rate, to test the system, shall be as a minimum, represent full scale operation of 400 lbs/min. for one minute, followed by 80 lbs/min. for the balance of the test at a full-scale load of 4,700 lbs.
 - 3. Replace dry media after testing.
 - 4. Test Data shall include:
 - a. Media temperature
 - b. Air discharge temperature

- c. Combined chlorine gas and air volume flow rate at scrubber inlet throughout the test run.
 - d. Continuous recording of scrubber discharge chlorine gas concentration, measured to +/- 5 ppb accuracy.
 - 5. Conduct further tests to verify that the proposed scrubber system will perform as specified with media at a start-up temperature as low as -40°F without the requirement for supplemental heating.
 - 6. Test shall demonstrate a continuous air discharge containing less than 5 ppb.
 - 7. Test results shall demonstrate a continuous air discharge containing less than 5 ppb chlorine concentration throughout the equivalent design load (4,7000 lbs) portion of the test.
 - D. At the time of the tests make all adjustments necessary to place equipment in satisfactory working order.
 - E. Repair or replace as necessary and retest all items failing to pass required tests at no additional cost to Owner.
- 3.03 FIELD TOUCH-UP PAINTING:
- A. Field painting to be in accordance with Section 09 96 00.
 - B. No protective coating shall be applied to improperly prepared surfaces.
 - C. Application of prime coats shall be accomplished immediately after any area has been prepared.
 - 1. No discoloration of the cleaned areas may have occurred prior to the application of the prime coat.
 - D. Color of ductwork, stack, and media tank as selected by owner.
 - E. After installation and acceptance testing by the Engineer apply touch-up paint to all scratched, abraided and damaged shop painted surfaces. Coating type and color shall match shop painting.
- 3.04 CONTRACT CLOSEOUT:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 44 42 13.03

FLOATING SUPERNATANT DECANter

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide and test three (3) floating decaners to extract supernatant from the backwash waste holding tanks. Decanter will feed pump suction for backwash recycling.
- B. The decanter shall be designed to be capable of withdrawing the effluent at an average rate of 2083 gallons per minute.
- C. Provide decaners, supports, and appurtenances as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

- A. American Society for Testing and Materials (ASTM):
 - 1. A240: Specification for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
 - 2. A295: Standard Specification for High-Carbon Anti-Friction Bearing Steel
 - 3. A530: Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.
 - 4. A554: Standard Specification for Welded Stainless Steel Mechanical Tubing

1.03 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00:
 - 1. Certified shop and erection drawings.
 - 2. Shop drawing data for accessory items.
 - 3. Manufacturer's literature as needed to supplement certified data.
 - 4. Operating and maintenance instructions and parts lists.
 - 5. Listing of reference installations as specified with contact names and telephone numbers.
 - 6. Shop and Field inspections reports.

7. Recommended spare parts.
8. Recommendations for short and long term storage.
9. Special tools.
10. Shop and field testing procedures and equipment to be used.
11. Manufacturer's product data and specifications for shop painting.
12. Provide a listing of the materials recommended for each service specified and indicated.
13. The latest ISO 9001 series certification or quality system plan.
14. Catalog cuts and technical data for expansion joints, couplings, gaskets, pipe supports and other accessories.

B. Material Certification:

1. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
2. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
3. Failure to include all drawings or a statement applicable to the equipment specified in this section will result in submittal return without review until a complete package is submitted.
4. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked and indexed to indicate requested deviations and clarifications from the specified requirements.
 - a. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 - b. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in

submittal return without review until marked up specifications and justifications are submitted in a complete package.

1.04 SPARE PARTS:

- A. Comply with requirements specified in Section 01 61 00.

1.05 QUALITY ASSURANCE:

- A. Provide in accordance with Section 01 43 00 and as specified herein.
- B. Provide manufacturer's certification in writing, that materials meet or exceed minimum requirements as specified.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 60 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Parkson
- B. Evoqua.
- C. Sanitaire
- D. Or, pre-approved equal

2.02 DECANTER MATERIALS AND FABRICATION:

- A. Decanters:
 - 1. Fixed decanters will not be acceptable
 - 2. Each decanter shall consist of a withdrawal manifold with orifices, a single foam filled float, and shall be capable of intermittent operation.
 - 3. The decanter assembly shall be constructed of machine filament wound, fiberglass reinforced, thermosetting resin pipe fabricated in strict accordance with ASTM Specification D-2996-01.
 - 4. Each orifice shall allow equal flow into the draw tube. The hydraulic differential provided shall be a maximum of 2.0 feet (plus pipe friction losses) determined as the differential head, under flowing conditions, between backwash waste tank bottom water level and backwash recycle pump suction.

5. The draw tube, containing the orifices for removal of supernatant shall be integrally attached to the foam filled float such that the float remains level throughout the full range of operation, and to maintain submergence of the orifices of the main body will be connected to the effluent piping by means of an 12" flanged stub.
6. The effluent pipe shall include a "knee" joint to allow vertical movement. The "knee" joint shall be wire reinforced rubber hose with a flange at each end, and include a support mechanism that allows vertical articulation, but precludes lateral or twisting movement.
7. Hose shall be suitable for abrasive materials, and shall be rated at 30 inches mercury vacuum and 15 PSI working pressure.
8. The effluent pipe shall be provided with a flanged connection for mounting the decanter system to the installed pipe through the basin wall.
9. Flange connection shall be in accordance with ANSI standard 150-pound bolt pattern. Hardware at this flanged connection interface shall be furnished by the contractor.
10. Decanters shall include assembly joints as necessary to fit through a 48"x72" access hatch should removal/installation of the decanter through the hatch be required.

B. Supports:

1. All necessary supports for the decanter mechanism shall be provided. Supports shall be constructed of 304 Stainless Steel
2. The supports will be located on the basin floor, and will support the decanter mechanism when the basin is dewatered
3. The supports shall consist of a support plate welded to a supporting base. The base shall be anchored with anchor bolts and grouted in place, if necessary. Fastening hardware shall be Type 18-8 stainless steel.

2.03 SHOP PAINTING:

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09 96 00.
- B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment is accepted.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Before assembly, remove dirt and chips from inside pipe and fittings.
- B. Install all items in accordance with manufacturer's printed instructions and as shown and specified.

3.02 FIELD TOUCH-UP PAINTING:

- A. After installation and testing witnessed by the Engineer, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

3.03 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 46 21 24

SELF-CLEANING STRAINERS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide and install thirteen (13) motorized automatic self-cleaning strainers and appurtenances for straining surface water prior to feeding ultrafiltration membrane equipment.
- B. Motorized automatic backwashing strainers shall be complete with all accessories and appurtenances (including, but not necessarily limited to electric motor, shafting, and safety guard). The starters will be provided by the Electrical Contractor in a smart MCC allowing communication and control over the plant network. The actuated valves and programming will be performed by the OEM. The General Contractor will provide all other valves.

1.02 REFERENCES:

- A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to Division 01 General Requirements.
- B. Refer to Section 40 23 19.05 for Process Piping and Appurtenances requirements.
- C. Refer to Section 40 23 13.01 for Process Valves and Appurtenances requirements, including pneumatic actuators.

1.03 SUBMITTALS:

- A. Comply with the requirements specified in Section 01 33 00.
- B. Shop Drawings and Product Data
 - 1. Make, model, weight and horsepower of each equipment assembly.
 - 2. Manufacturer's catalog information, descriptive literature, specifications and identification of materials of construction.
 - 3. External utility requirements such as air, water, power, drain. etc., for each component.
 - 4. Functional description of internal, external instrumentation and controls to be supplied including list of parameters monitored, controlled, or alarmed.
 - 5. Control panel arrangement drawings.
 - 6. Power and control wiring diagrams, including terminals and numbers.

7. Shop and field painting systems proposed: Include manufacturer's descriptive technical catalog literature and specifications.

- C. Operation and Maintenance Manual: Provide Operation and Maintenance Manuals in accordance with Section 01 78 23.

1.04 SPARE PARTS:

- A. Comply with requirements specified in Section 01 61 00.
- B. Provide the following spare parts:
 1. Three sets of retaining rings, inspection cover gasket, cover o-ring, packing set, and drum seal ring
 2. Two bearing sets.
 3. One complete set of any special tools required to maintain or dismantle the strainer.
- C. All spare parts shall be packed for long-term storage in containers that are clearly identified with indelible markings.
- D. Parts shall be of the same manufacturer and quality as those provided with the equipment.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Quality Control Submittals
 1. Written certification that the factory-applied coating system(s) is identical to the requirements specified.
 2. Special shipping, storage and protection, and handling instructions.
 3. Manufacturer's written/printed installation instructions.
 4. Routine maintenance requirements prior to plant startup.
 5. Manufacturer's Certificate of Authorization from ASME and ISO 9001.
 6. Shop Test Reports of motor run test, hydrostatic pressure test and dimensional verification.
 7. Operation and maintenance manuals.
- C. Installer's Qualifications: The installer shall be approved by the strainer manufacturer, with final installation inspected and approved by a representative of the strainer manufacturer.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10 and as specified herein.
- B. Handling, delivery, and storage of the strainer equipment shall be in compliance with the manufacturer's written instructions. All equipment items shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and such equipment is ready for operation.
- C. All equipment and parts shall be properly protected against any damage during storage at the site. Factory-assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.
- D. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion. Strainer and motors shall be stored in a dry sheltered environment, protected from weather.

1.07 WARRANTY:

- A. The supplier shall guarantee in writing that the equipment furnished is appropriate for the intended service and shall be free of manufacturing and fabrication defects in material and workmanship for a period of 1 year after the equipment is satisfactorily placed in service.

PART 2 - PRODUCTS

2.01 SHOP PAINTING

- A. Furnish manufacturer's standard baked enamel finish. Color as selected by Owner from available colors.

2.02 AUTOMATIC STRAINERS FOR SURFACE WATER:

A. General

- 1. Fluid: Surface water from the Provo River.
- 2. Use: Potable water, all materials must be NSF approved.
- 3. Design Pressure: 150 psi.
- 4. Operating Pressure (inlet): 15 to 50 psi.
- 5. Fluid Temperature: 34 deg F minimum, 90 deg F maximum.

B. Sizing Information

- 1. Strainer Quantity: 13

2. Design flow: 2,500 gpm minimum rating per strainer
3. Maximum clean differential pressure loss: 3 psi at 1,800 gpm per strainer.
4. Process Connection: 10-inch flanges, faced and drilled, 150-pound. ANSI B16.5.
5. Straining element rating: 200 micron

C. Strainer Construction

1. Body: Fabricated carbon steel or cast iron, epoxy-lined.
2. Cover: Fabricated carbon steel or cast iron, epoxy coated.
3. Shaft: Carbon steel, ceramic coated at packing area.
4. Straining Element: 304 stainless steel, reinforced.
5. Backwash shoe: cast iron
6. Clear inspection window over backwash shoe.
7. Internal Fasteners: 316L stainless steel
8. Retaining Rings: Delrin.
9. Packing: Chevron pressure seal

D. Motors: Maximum 1 HP each, 460 volts, 3-phase, 60 Hz, TEFC.

E. Manufacturer

1. S.P. Kinney.
2. Bollfilter.
3. Eaton.

2.03 CONTROLS:

- A. OEM shall supply a control system for the initiation of backwashes. These can be initiated automatically by high differential pressure condition, timed operation, initiated manually by the operator.
- B. See full control description and I/O requirements in division 40 specifications.

2.04 APPURTENANCES:

- A. Backwash Monitoring and Control Devices

1. Provide a differential pressure switch with visual indication of differential pressure for measurement of differential pressure across the strainer and initiation of backwash cycle. Provide valves for isolation and flushing of the instrument.
 2. Mount differential pressure switches, and valves on each unit using stainless steel tubing and fittings.
- B. Lifting Lugs: Provide suitably attached for all equipment assemblies and components weighing over 100 pounds.
- C. Equipment Anchor Bolts: Type 316 stainless steel sized by equipment manufacturer at least 1/2 inch in diameter, or as shown.
- D. Equipment Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel(s) in a readily visible location. Plate shall bare 3/8-inch-high engraved block type black enamel filled equipment identification number and letters.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Follow the manufacturer's recommended procedures for testing, adjusting, and placing of equipment into proper operation.
- B. Install as shown on the drawings, approved shop drawings, and as recommended by the manufacturer.
- C. Route the backwash outlet piping to the waste tanks as shown on the drawings.
- D. Provide all necessary power and signal wiring for operation of the strainers and backwash control valves.
- E. Check condition of bearings in strainer. Add lubricant according to manufacturer's recommendations.
- F. Check for proper motor rotation.

3.02 MANUFACTURER'S SERVICES:

- A. Comply with requirements specified in Section 01 43 00.
- B. The OEM shall provide at least one (1) qualified field representatives to be on-site to coordinate and supervise the installation (1 day), startup and testing (3 days) of the strainers.
- C. Provide 4 hours of on-site Owner training following commissioning of the strainers, which shall be provided in one session

- D. Startup services and training of Owner's personnel shall be at such times as requested by the Owner.
- E. Additional time required to perform these services shall be at no additional cost to the Owner. The Owner shall be credited for the unused portion of startup services.

3.03 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 46 31 11.01

CHLORINE GAS FEED EQUIPMENT AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Provide and test chlorination equipment and appurtenances, as indicated and in compliance with Contract Documents.
- B. Provide chlorination system complete. And before acceptance make each system fully operational and ready for use by the Owner.
- C. Chlorine for testing to be supplied by the Owner. After testing is completed, chlorine is to be left for use by the Owner.
- D. Chlorination systems to meet the following regulatory requirements:
 - 1. The Utah Department of Environmental Quality, "R309-200. Monitoring and Water Quality: Drinking Water Standards" (Latest Revisions).
 - 2. The Utah Department of Environmental Quality, "R309-520. Disinfection" (Latest Revisions).

1.02 REFERENCES:

- A. ASTM International (ASTM):
 - 1. A53/A53M: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - 2. A105/A105M: Standard Specification for Forgings, Carbon Steel, for Piping Components.
 - 3. A216/A216M: Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding for High Temperature Service.
- B. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1, Rules for Construction of Pressure Vessels.
 - 2. B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
- C. The Chlorine Institute, Inc.

1. Chlorine Manual.
- D. International Organization for Standardization (ISO):
 1. 9001: Quality Management Systems - Requirements
- E. National Electrical Manufacturers Association (NEMA):
 1. 250: Enclosures for Electrical Equipment (1000 Volts Maximum)
 2. ICS 1: Industrial Control and Systems General Requirements
- F. National Institute for Occupational Safety and Health (NIOSH):
 1. Title 42 CFR Part 84: Approval of respiratory Protective Devices
 2. National Personal Protective Technology Laboratory (NPPTL) Certified Equipment List
- G. Uniform Fire Code:
 1. Article 80
 1. 1: Fire Code
- I. Standard Fire Code.
- J. Building officials and Code Administration of America (BOCA).
- K. Utah Department of Environmental Quality (UDEQ)
 1. R309-200: Monitoring and Water Quality: Drinking Water Standards
 2. R309-520: Disinfection
- 1.03 SUBMITTALS:
 - A. Submit the following shop drawings in accordance with Section 01 33 00:
 1. Prior to initial submittal, arrange conference in Engineer's office with Engineering Representatives of equipment vendor who are familiar with specification to discuss overall job concept.
 2. When the Contractor proposes equipment which requires an arrangement differing from that indicated on the drawings or specified, prepare and submit for review detailed structural, mechanical, and electrical drawings and equipment lists, utilities consumption schedule and operating instructions, showing necessary changes and embodying special features of the equipment he proposes to furnish. Make changes, if accepted at no additional cost to Owner.

3. Provide calculations for chlorine ejector/injector.
 4. Provide ejector/injector curve with operating point indicated.
 5. Certified shop and working drawings.
 6. Certified setting plans, with tolerances, for anchor bolts.
 7. Operating and maintenance instructions and parts lists.
 8. Shop drawings details for accessory items.
 9. Number and identify components to correspond with terminology on drawings. Use these numbers on all submittal sheets and shop drawings.
 10. Recommendations for short and long term storage.
 11. Sales bulletins or other general publications are not acceptable as submittals for review except where necessary to provide supplemental technical data.
 12. ISO 9001 certification or other quality control manual demonstrating a complete system for quality management.
 13. Chlorination equipment manufacturer must be capable of providing a list of customers using at least five (5) similar system for at least ten (10) years.
 14. Material Certification:
 - a. Provide certification from the manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of three (3) years. Provide proposed materials at no additional cost to the Owner.
 - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
 15. Certified results of factory tests.
- B. A copy of the contract mechanical process, electrical and instrumentation drawings, with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required".

1. Failure to include all drawings applicable to the equipment specified in this section will result in rejection of the entire submittal with no further review.
- C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations and clarifications from the specified requirements.
1. If deviations and clarifications from the specifications are indicated, therefore requested by the Contractor, provide a detailed written justification for each deviation and clarification.
 2. Failure to include a copy of the marked-up specification sections and or the detailed justifications for any requested deviation or clarification will result in rejection of the entire submittal with no further review and consideration.

1.04 SPARE PARTS:

- A. Provide in accordance with Section 01 61 00 and as specified herein.
- B. Furnish spare parts, identical and interchangeable with similar parts installed in work:
1. Three sets of spare gaskets.
 2. Two spare auxiliary tank valves for ton containers.
 3. 20 spare feet of drain hose and 20 spare feed of chlorine gas tubing.
 4. Two chlorine header-to-cylinder whips transfer hoses.
 5. Two spare switches for high/low vacuum alarm complete with diaphragm seals.
 6. One chlorine pressure gauge complete with diaphragm seal.
 7. One emergency repair kit for ton containers.
 8. Three vacuum regulators for 1-ton containers
- C. Provide all other manufacturer's recommended spare parts necessary to maintain each piece of equipment for period of one year.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00
- B. Do work required by and in accordance with applicable State and local codes; arrange for permits, inspections and tests required by these codes. Provide systems and items of equipment that conform to applicable safety standards including those for safety of personnel.

- C. Provide components to manufacturer's standard for service specified and indicated unless otherwise required.
 - D. Provide equipment of manufacturers' latest and proven design. Unit to be a standard cataloged product and modified as specified and indicated.
 - E. Services of Manufacturer's Representative as stated in Section 01 43 00 and as specified herein.
 - F. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
 - 1. Service Technician must have a minimum of five (5) years of experience, all within the last seven (7) years, on the type and size of equipment.
 - 2. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.
 - 3. Installation: Inspect system arrangement, interconnecting tubing and piping, and certify proper installation has been performed:
 - a. 1 person-day.
 - 4. Functional Testing and Field Testing: Calibrate, check alignment and perform a functional test to include all items specified. Perform field performance testing of equipment specified.
 - a. 2 person-days.
 - 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials and preparation to lead and training.
 - a. 1 person-day.
 - 6. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 - 7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
- 1.06 DELIVERY, STORAGE AND HANDLING:
- A. Comply with the requirements specified in Section 01 66 10.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- A. Provide a complete chlorine gas system as shown on the drawings and as specified herein. System includes cylinder scales and trunnions, vacuum regulators and automatic switchover equipment, chlorinators, injectors, gas and liquid piping / tubing and valves, gauges and analyzers, leak detection and alarm equipment, safety equipment, and other accessories for a complete functional and operable system. 1-ton chlorine gas cylinders will be provided by the Owner.

2.02 MANUFACTURERS:

- A. Pre-qualified chlorination system equipment manufacturers are listed below. Miscellaneous components of the system that are not a product of the selected manufacturer may be provided by the Contractor or the Manufacturer. Manufacturer and Contractor to coordinate their scopes of supplier prior to bid.

- 1. Wallace & Tiernan (Evoqua Water Technologies, LLC).

2.03 PIPING:

A. General:

- 1. Piping in accordance with Section 40 23 19.05.
 - 2. Cold bending of pipe NOT ACCEPTABLE.
 - 3. Piping passing through walls or floors of chlorine storage area and chlorinator room caulked gas tight as specified for plumbing work.
 - 4. Arrange piping at the points of application as indicated on drawings. Sizes and capacities not specified herein are indicated on drawings.

B. Liquid chlorine and chlorine gas under pressure:

- 1. Schedule 80 seamless steel pipe.
 - 2. Conform to ASTM A53/A53M.
 - 3. Manifold at ton containers mounted on protecting angle-iron support frame.
 - 4. Manufacturer's standard whips.

C. Chlorine gas under vacuum:

- 1. Refer to drawings for locations of material type.
 - 2. Polyethylene (PE) Tubing 1/2-inch and greater.

- a. Conform to AWWA C901 for PE Tubing.
- 3. Schedule 80 PVC Pipe 1/2-inch and greater.
 - a. Conform to ASTM D1784 and ASTM D1785 for SCH 80 PVC.
- D. Chlorine solution:
 - 1. Schedule 80 PVC Pipe 1-inch and greater.
 - 2. Conform to ASTM D1784 and ASTM D1785.
- 2.04 VALVES:
 - A. Chlorine Gas Under Pressure:
 - 1. Whip to manifold valves standard Chlorine Institute Valves.
 - 2. Whip to container valves standard Chlorine Institute auxiliary yoke-type tank valves.
 - B. Chlorine gas under vacuum and chlorine solution:
 - 1. Polyvinylchloride (PVC) Type 1, Grade 1 valves as specified under Section 40 23 13.01.
 - C. Vacuum Relief Valve:
 - 1. On solution discharge header line from injectors.
 - 2. Relieve excess vacuum resulting from negative head in solution line.
- 2.05 FITTINGS:
 - A. Liquid Chlorine and Chlorine Gas Under Pressure:
 - 1. 3000-lb. forged carbon steel socket weld fittings.
 - 2. 2000-lb. forged carbon steel screwed fittings.
 - 3. 300-lb. ANSI forged carbon steel flanges or Schedule 80 seamless butt weld fittings for pipe larger than 1-1/2-inch in size.
 - 4. Use teflon tape mixture of linseed oil and white lead or mixture of linseed oil and graphite on male threads where screwed fittings required.
 - 5. Flange gaskets for chlorine of lead containing 3 percent antimony.
 - 6. 1/16-inch thick gaskets for pipe smaller than 2-inch.

7. 1/8-inch thick gaskets for pipe 2-inch and larger.

B. Pressure Gages:

1. Install with header type isolation valves of suitable material.
2. Diaphragm type.
3. Silver or tantalum diaphragms.
4. Fluorocarbon oil filling.

C. Pressure Switches:

1. Install as indicated.
2. Diaphragm seal to protect activating elements.
3. Normally open contacts with field adjustable closure setting.
4. Wired to alarm high gas pressure in manifold.

2.06 CHLORINATION SYSTEM EQUIPMENT:

A. Scales:

1. Manufacturer
 - a. Force Flow
 - b. Eagle Microsystems
 - c. Engineer-Approved Equal
2. 1-Ton Container Scales:
 - a. The scale shall be universal-type suitable for floor mounting as shown on the drawings.
 - b. Platform size shall be approximately 80 inches x 30 inches and capable of holding and measuring up to 2-tons (4,000 pounds).
 - c. Platform and all metal components shall be made corrosion-resistant with a two-coat vinyl epoxy primer.
 - d. Platform shall have zinc plated steel rollers with bronze bushed bearings and grease fittings and locking feature furnished to allow for easy container rotation and to restrain container once set in place.

- e. Scale shall be of the single load cell design. Weight shall be transferred via lever(s) to a single, NTEP approved load cell of the shear beam, strain gauge type. Flexible cable shall connect load cell to indicator to allow easy remote installation of readout. Cable length shall be 20 feet.
 - f. Scale furnished with programmable digital readout/electronic load cell type.
 - g. The Contractor shall supply three tank restraint straps with ratchet buckles for securing the containers in place.
3. Chemical Weight Scale System Indicator
- a. Digital readout with at least 1/2-inch characters, LCD or LED display up to seven (7) digits and in pounds.
 - b. Readout programmable from panel front for units, tare and zero adjustments.
 - c. Powered by 240 VAC or rechargeable battery and capable of retaining stored data for 2 days.
 - d. Indicator shall carry CE marking and shall be housed in a NEMA 4X, UL approved enclosure.
 - e. Indicator shall independently monitor up to four (4) scales.
 - f. Provide, 4-20 mA direct current output for interfacing with SCADA.
 - g. Each indicator shall have up to four (4) adjustable set points for alarms or liquid level control.

4. Schedule

Scale Equipment Tag No.
CGC-0301-1 / WE 0301-1 (Weigh Scale 1)
CGC-0301-2 / WE 0301-2 (Weigh Scale 2)
CGC-0301-3 / WE 0301-3 (Weigh Scale 3)
CP-0301-1 (Chlorine Gas Weigh Scale System Indicator)

B. Locking Storage Trunnions

- a. Epoxy power coated ASTM A36 steel frames with zinc plated steel rollers with bronze bushed bearing and grease fittings furnished and installed to restrain stored ton containers not in use. One of four rollers shall have a locking pin to prevent tank rotation when containers are not in use.
- b. The Contractor shall supply eight (8) storage trunnions.

- c. The Contractor shall supply eight tank restraint straps with ratchet buckles for securing the containers in place.

C. Automatic Change Over System: (Gas Withdrawal)

1. Furnish units as indicated on Drawings. Suitable for installation on one-ton chlorine gas cylinders.
2. Factory preset to reduce chlorine gas pressure to a vacuum.
3. Furnish vacuum regulating valve body of high tensile cast iron and regulatory diaphragm of Hastelloy "C".
4. Vacuum regulating valve designed to automatically switch from on-line container(s) to reserve container(s) when on-line supply is exhausted. Design to allow manual shutoff, and withdrawal from both supplies until fully exhausted.
5. Equipped with traps and filters to exclude impurities from system.
6. Standby relief device to vent in the event of pressure check valve malfunction.
7. Provide 120 V power supply for each regulator.
8. Each vacuum regulator shall be connected to a vent line and combined common header which is routed to the outside of the chlorine gas storage room above grade per drawings and in accordance with Section 40 23 19.05. The termination point of the common header vent end shall be covered with No. 14, Type 304 stainless steel mesh, non-corrodible screen.
 - a. Tubing: 3/8-inch polyethylene tubing
 - b. Common Header: 1-inch SCH80 PVC
9. Vacuum Regulator Schedule

Tag No.	Capacity
RGL-0301-1	500 PPD
RGL-0301-2	500 PPD
RGL-0301-3	500 PPD
Spare regulators (3)	500 PPD

D. Chlorinators:

1. Visible flow, solution feed, vacuum type arranged for automatic pacing from 4-20 mA flow transmitter signal and with manual dosage adjustment.

2. All necessary accessories included. Signal wiring shielded. All necessary relays included to eliminate interference with flow transmitter.
3. Chlorine gas metered under partial vacuum created by injector located near each chlorinator.
4. Each chlorinator equipped with necessary piping and fittings. Chlorinators contain automatic safety features to prevent escape of chlorine gas in event of (1) loss of vacuum, (2) failure of water supply, (3) blockage of solution line, and (4) breakage of any part of vacuum system.
5. Each chlorinator includes vacuum breaker to prevent excess vacuum.
6. Chlorinator components mounted in self-contained, corrosion-resistant wall or floor mounted cabinet as indicated.
7. Each chlorinator paced by motorized plug positioner. Flow pacing signal 4-20 mA direct current signal.
8. Furnish each chlorinator with pressure indicators to indicate injector vacuum and pressure of chlorine supply to chlorinator. Furnish chlorinators with AUTOMATIC/MANUAL switch. Wire AUTOMATIC/MANUAL switches to provide pacing signal in AUTOMATIC positions.
9. Each chlorinator equipped with alarm actuators to indicate loss of vacuum, and excess vacuum.
10. Provide 120 V power supply for each chlorinator.
11. Schedule

Tag No.	Service	Chlorinator and Metering Tube Capacity
CL / CP-0301-4	CIP Tank 1 & 2	500 PPD
CL / CP-0301-5	CIP Tank 1 & 2	500 PPD
CL/ CL-0301-6	Treatment Process Chlorination	750 PPD
CL / CL-0301-7	Treatment Process Chlorination	750 PPD

E. Injectors

1. Hydraulically operated injectors furnished for each chlorinator wall or pipe mounted units and sized to ensure optimum water usage and vacuum. Injectors sized to operate against a back pressure at point of injection, at flow rate and supply pressure indicated on schedule.

2. Schedule

Injector Schedule				
Tag No.	Service	Back Pressure (psig)	Supply Pressure (psig)	Flow Rate (gpm)
INJ-0301-12	CIP Tank 1 & 2	5	70	15
INJ-0301-13	CIP Tank 1 & 2	5	70	15
INJ-0301-14	Chlorination	6	37.5	30
INJ-0301-15	Chlorination	6	37.5	30

F. Rotameters:

1. Visual flow indicating rotameters suitable for chlorine solution service each having a range suitable to dispense the full output of one of the chlorinators furnished and calibrated in gallons per minute.
2. Rotameters furnished with all mounting hardware.
3. Size and configuration of rotameters as indicated on the drawings.
4. Provide engraved plastic nameplates furnished which indicate point of application served by each rotameter, and suitably affixed above each rotameter.
5. Schedule

Rotameter Schedule		
Service	Tag No.	Flow Range (gpm)
CIP Tank 1 & 2	FI 0301-12	0 - 15
CIP Tank 1 & 2	FI 0301-13	0 - 15
Chlorination	FI 0301-14	0 - 30
Chlorination	FI 0301-15	0 - 30

G. Chlorine Gas Leak Detectors:

1. Solid state type consisting of remote sensing unit (probe) and electronic control unit (NEMA 4X housing).
2. Sensing probe (detector unit) located approximately 6 inches above the floor adjacent to the chlorine supply as shown in the contract drawings.
3. Each receiver control box shall be located in the vicinity of the sensor unit at an exterior entrance to the chlorine gas storage room.

4. Receiver control box will detect 0.5 PPM to 10 PPM (by volume of air) and actuate appropriate alarm relays and lights. Two additional sets of relay contacts (unpowered) to permit operation of external alarms and other equipment. Contacts rated at 250V, 10 A.
 - a. The warning setpoint (user-adjustable) shall be 0.5 PPM (by volume of air).
 - b. The alarm setpoint shall be 1 PPM (by volume of air).
5. In the event of power failure, two integral batteries will maintain operation for up to four hours.
6. Control unit equipped with test switch to check operation of alarm circuits and control unit itself.
7. Upon detection of gas at the warning or alarm setpoint, control unit to send signal to activate the emergency dry gas scrubber and sound the alarm horns.
8. Schedule

Tag No.
AE 0300-1 / AIT 0300-1
AE 0300-2 / AIT 0300-2

H. Standby Chlorine Gas Masks:

1. Manufacturers:
 - a. Scott Safety.
 - b. MSA (Mine Safety Appliances Co.)
 - c. Globe Safety Products Inc.
 - d. American Optical Corp., Safety Products Div.
2. 30-minute capacity self-contained breathing apparatus
 - a. Provide a self-contained unit of type approved by U.S. Bureau of Mines, Title 42 CRF part 84, and NPPTL Certified Equipment List for use for minimum of 30 minutes severe service in toxic and oxygen deficient area. Full-vision face mask suitable for use by persons wearing eyeglasses, with shatterproof-glass eyepiece cushioned in rubber; molded rubber face piece with exhalation valves; and easily adjustable head straps. Breathing tube of corrugated, noncollapsible, flexible, chlorine-resistant material.
 - (1) Apparatus includes demand regulator with provisions to maintain positive static pressure in mask, manual bypass and pressure gage,

alarm, tubing, lightweight 45 cubic feet air cylinder with valve, and adjustable backpack harness with cylinder carrying frame, and complete with carrying case.

- b. Furnish one spare charged 45 cubic feet air cylinder complete with valve.
- 3. 5-minute capacity escape gas masks and bottles
 - a. Furnish three self-contained unit of type approved by U.S. Bureau of Mines, Title 42 CRF Part 84, and NPPTL Certified Equipment List for use for 5 minutes severe service in toxic and oxygen deficient area. Full-vision face mask suitable for use by persons wearing eyeglasses, with shatterproof-glass eyepiece cushioned in rubber; molded rubber face piece with exhalation valves; and easily adjustable head straps. Breathing tube of corrugated, noncollapsible, flexible, chlorine-resistant material.
 - (1) Each apparatus includes demand regulator with provisions to maintain positive static pressure in mask, manual bypass and pressure gage, tubing, lightweight 15 cubic feet air cylinder with valve, and adjustable backpack harness with cylinder carrying frame, and complete with carrying case.
 - b. Furnish three spare 5-minute escape bottles
- 4. Provide suitable wall mounting equipment and hardware for gas masks and air cylinders. Installed location to be as directed by the Owner.
 - a. AO Safety (Aearo Technologies / 3M)
 - b. AO Safety (Aearo Technologies / 3M)

I. Chlorine Gas Leak Detection Kit

- 1. Provide an aqua ammonia test kit for detecting chlorine gas leaks which includes the following:
 - a. One, 16-oz. wash bottle with an ammonium hydroxide hazard label
 - b. A minimum of five cotton swabs
 - c. 16-oz. of aqua ammonia, commercial 26 degree Baume (29.4 percent) ammonia.

J. Vacuum Alarm Switch:

- 1. Switches located on chlorinators, install and wire into control unit as specified by supplier.

2. Provide suitable hardware for mounting the equipment to the wall or Unistrut frame.
 - a. Connect Teflon tubing from the vacuum switch to the vacuum line.
 - (1) 0.158-inch inner diameter, 0.236-inch outer diameter Teflon tubing
 - b. Use flexible conduit wiring as shown on drawings.
3. Schedule

Schedule	
Location	No.
Gas Vacuum Feed Line	PSH 0301-3
Chlorinator 1	PSH 0301-4
Chlorinator 2	PSH 0301-5
Chlorinator 3	PSH 0301-6
Chlorinator 4	PSH 0301-7

K. Audible Alarm Horn

- a. Provide alarms as indicated on the drawings to produce no less than 110 decibels from 1 meter distance and shall sound when activated by detection of chlorine gas by the analyzer.
- b. Mount alarm on wall at location directed by engineer.
- c. Alarms shall be suitable for 120 VAC power and powered by the associated chlorine gas analyzer.
- d. Quantity: Two (2)

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install all equipment and connecting piping in accordance with manufacturer's instructions and as indicated.
- B. Install all chlorine injectors at a slight, upward slope so that the discharge end is higher than the inlet end to prevent air entrapment in the injector throat. Field route all piping connecting to the injectors with suitable deflection to accommodate the slight, upward slope through the injectors.

- C. Prior to testing and start-up, inspect the installation to verify the system is ready for complete testing and calibration of equipment.
- D. Testing to be done with chlorine gas. Chlorine gas will be supplied by the Owner.

3.02 CLEANING:

- A. Work to be done in accordance with Chlorine Institute pamphlets.
- B. Carefully clean all portions of chlorine systems before use so that chlorine will not react with any cutting oil, grease and other foreign and oxidizable materials. Clean by pulling through each length of pipe a lint-free cloth saturated with trichloroethylene or other suitable chlorinated solvent. Do not contact any plastic pipe or equipment with solvent. Hydrocarbons or alcohols are NOT ACCEPTABLE because residual solvent may react with chlorine. Dismantle and clean new valves and other equipment before use. If valve packings are oily or dirty, repack valves with manufacturer's recommended packing . Test valves with clean, dry 300-psi air for seat tightness as specified hereinbefore.
- C. Chlorinated solvents can produce very serious physiological effects unless used in strictest compliance with the solvent manufacturer's safety recommendations. Instruct workmen in the proper use, disposal and handling of these solvents.

3.03 FIELD QUALITY CONTROL: (CALIBRATION AND ACCEPTANCE TESTING)

- A. No form of energy shall be turned on to any part of the system prior to receipt by Engineer of certified statement of approval of installation from Contractor containing his supplier's authorization to energize system, except that supplier's servicemen may do so for purposes of check-out.
- B. After installation, and in presence of the Engineer, test all pipelines for tightness in acceptable manner. Furnish suitable testing plugs or caps, all necessary pipe connections, test fluids, gages, other equipment and all labor required for these tests.
- C. Remove or valve off from lines all instrumentation and appurtenant equipment which is incapable of withstanding the test pressures.
- D. Hydrostatically test all PVC chlorine solution piping with water to 100 psig pressure. Prior to test, remove or isolate solution rotameters and any other devices which may be incapable of withstanding test pressures.
- E. Then pressurize chlorine supply system to 300 psig with dry air or nitrogen and test for leaks by application of soapy water to outside of all joints. After pressure testing all piping gradually introduce chlorine gas and test the system for leaks as described below. Make no attempt to repair leaks by welding unless all chlorine gas has been completely purged from the system. When leaks have been repaired, retest the line.

- F. Test for chlorine leaks as follows; tie a cloth to end of a stick, soak cloth with aqua ammonia, and hold close to suspected area. A white cloud will result if there is any chlorine leakage. Use commercial 26 degree Baume (29.4 percent) ammonia.
 - G. Test and dry all piping as outlined in the latest edition of the Chlorine Institute Manual.
 - H. At the time of the tests make all adjustments necessary to place equipment in satisfactory working order.
 - I. Repair or replace as necessary and retest all items failing to pass required tests at no additional cost to Owner.
 - J. Test chlorine leak detectors.
 - K. After installation of equipment in the presence of the Engineer, operate each unit to demonstrate its ability to operate without leakage and to perform its specified functions satisfactorily.
 - L. Have manufacturer's service engineer test pacing and trimming system at 10, 50 and 80 percent of scale to demonstrate that chlorinator response to pacing and trimming signals is within manufacturer's published accuracy statement.
 - M. Test loss of vacuum switches and alarms, and loss of chlorine and high gas pressure switches and alarms by shutting down water supply to each chlorinator and altering chlorine gas supply. Repeat tests as necessary and correct defects.
 - N. Clean, repair to satisfaction of the Engineer, or replace all equipment or property damaged by testing procedures at no additional cost to the Owner.
 - O. Operate chlorinators over 8-hour period at fixed rates to demonstrate that feed rate is within manufacturer's published range.
- 3.04 FIELD TOUCH-UP PAINTING:
- A. After installation and acceptance testing by the Engineer apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.
- 3.05 CONTRACT CLOSEOUT:
- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 46 31 53

OZONE GENERATING AND FEED EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Furnish, install, and commission a complete ozone delivery system including the following:
 - 1. Liquid and gaseous oxygen storage and conditioning equipment including LOX storage tank, vaporizers, electric trim heater, oxygen pressure regulating manifold, and nitrogen boost system.
 - 2. Ozone generation system including ozone generators and power supplies, closed loop chillers, and ozone gas monitoring and flow control manifolds.
 - 3. Ozone injection and pressurized solution injection system including a skid with ozone gas flow control, motive water booster pumps, venturi style ozone gas injector, and related instruments, piping, and valves. Inject system also includes an off-skid pipeline flash reactor to be installed in the field by the Contractor.
 - 4. Ozone off-gas handling equipment including de-misting units and ozone destruct units.
 - 5. All associated analog and digital analytical instruments including gauges, pressure and temperature transmitters, flow meters, dew point analyzers, ozone analyzers, and ambient air ozone detectors.
 - 6. System controls package.

1.02 REFERENCES:

- A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to Division 01 General Requirements.

1.03 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00:
 - 1. Sustainable Design Submittals.
 - 2. Drawings, including process and instrumentation diagrams (P&ID)
 - 3. Cut sheets
 - 4. Performance curves

5. Spare parts list
6. Testing documents
7. Schematic electrical diagrams.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00 and provide the following:
 1. O2 Filter Element
 2. O3 Analyzer filter
 3. Solenoid Valve
 4. Solenoid Valve Coil
 5. One (1) each size fuse or circuit breaker
 6. Input Card
 7. Output Card
 8. Control Relay
 9. If the dielectrics do not have a ten-year non-prorated labor inclusive warranty, 10% spare dielectrics shall be provided.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Manufacturer's Qualifications
 1. The ozone generator system supplier (OSS) shall have experience in the design and manufacture of ozone generation systems for a minimum of ten (10) years and shall be able to demonstrate a minimum of twenty (20) installations in municipal water and/or wastewater applications.
 2. The Ozone Sidestream Dissolution System supplier shall have experience in the design and manufacture of ozone dissolution systems for a minimum of ten (10) years and shall be able to demonstrate a minimum of twenty (20) installations in municipal water and/or wastewater applications.
- C. Sustainability Standards Certifications.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10 and as specified herein.
- B. Assemblies and components provided by the OSS must be properly stored and protected during delivery and handling. Pay special note that some items are provided as cleaned and packaged for oxygen service. Integrity of oxygen cleaning must be maintained throughout storage and installation. Caution should be used to maintain quality of finish for all painted, or otherwise finished, surfaces.

1.07 PROJECT/SITE CONDITIONS:

- A. Ambient Conditions at a publicly owned water treatment plant in Provo, Utah.

1.08 WARRANTY:

- A. The Manufacturer shall provide a written warranty against defects in materials and workmanship. Manufacturer shall warrant the goods provided by the Manufacturer to be free from defects in materials and workmanship under normal conditions and use for a period of one (1) year from the date the goods are put into service. This warranty shall not apply to any goods or parts which have been altered, applied, operated or installed contrary to the Manufacturer's instructions or subject to misuse, chemical attack/degradation, negligence or accident.
- B. The warranty terms above shall apply to the Modular Ozone Generator Cells. Additionally, the dielectric elements of the Modular Ozone Generation Cells shall have a non-prorated labor inclusive warranty for a period of ten (10) years after being placed in service. OSS shall guarantee the specified mass transfer efficiency (MTE) for a period of 60 days following commissioning. The OSS must provide all corrective actions to equipment within their scope of supply to consistently achieve this MTE is failed to be met.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION:

- A. Description of primary components are included in this section.
 - 1. (1) Ozone Gas Sidestream Injection skid featuring eductors for liquid solution injection into a single Pipeline Flash Reactor located upstream of the ozone contactors. Injection skids shall also include flow and pressure monitoring.
 - 2. (1) Pipeline flash reactor for dissolution of ozone sidestream solution in to the 42" ozone contactor feed piping. The ozone sidestream dissolution system supplier, in conjunction with the Ozone supplier shall determine the number and size of injectors and nozzles based on injection requirements.

3. All manual and automatic control, isolation, and emergency shut-off valves and temperature/pressure safety relief valves as indicated on the drawings and as required for a functioning and automated system. Valves shown on the P&ID drawings which do not feature a tag number shall be provided by the OSS.
4. All analytical instruments including pressure transmitters, temperature transmitters, flow meters, dew point analyzers, flow and pressure switches, ozone gas detecting monitors, and ozone solution detecting monitors. Instruments shown on the P&ID drawings which do not feature a tag number shall be provided by the OSS.
5. Electrical controls with internal components for a complete and functional system.
6. The contractor shall furnish and install all piping, fittings, and valves which are not in the OSS scope of supply. The sizes of such piping shall be as recommended by the OSS based on volumetric flow rates of oxygen and ozone gas and as required to match connection sizes on supplied equipment. Any piping, fittings, and valves supplied by the Contractor to provide a complete and functional system shall be coordinated during bidding to fully determine the scope of OSS and Contractor supply.
7. Boundaries and equipment shown within the OSS scope of supply on the drawings are for reference and the OSS shall provide standard equipment adhering to these specifications.
8. OSS shall clearly identify which components are to be shipped loose for field installation and which are included pre-assembled. Additional cost incurred which is incurred for installation or wiring of any loose-shipped items provided by the OSS shall be performed at no additional expense to the Owner.

2.02 MANUFACTURERS:

- A. The OSS is responsible for supplying the equipment specified herein regardless of whether they are the equipment manufacturer or equipment provided by others.
- B. Ozone System Supplier
 1. Aqua-Aerobic Systems, Inc. ElectrOzone M-Series.
 2. Primozone.
- C. Ancillary equipment (furnished by OSS)
 1. Ozone Sidestream Dissolution System, including injection skid with pumps and accessories, and the Pipeline Flash Reactor.
 - a. Mazzei Injector Company

- (1) Refer to section 43 21 00.23 for specific requirements of Ozone motive water pumps
 - b. Mazzei is the basis of design. For any substitutions, the contractor shall submit a proposal for a substitution with engineering details no less than two weeks ahead of the bid date, for review and approval by the Engineer.
- 2. Liquid oxygen storage tank and vaporizers
 - a. Chart Industries
 - b. Approved Equal.
- 3. Closed Loop Chillers
 - a. MTA TAEevo Tech
 - b. Approved Equal

2.03 PERFORMANCE AND DESIGN CRITERIA:

- A. General description: Project includes two (2) parallel ozone contact basins designed to treat 15 MGD each, for a total of 30 MGD. Ozone is injected in to a 42" Pipeline Flash Reactor in the mainline that then splits flow into each ozone contactor. Ozone system is not for disinfection and is not designed as fully redundant.

The ozone generator shall be capable of producing the required amount of ozone as noted below.

- 1. Ozone generator capacity:
 - a. Number of generators shall be determined by OSS based on standard generator sizes and shall be two (2), three (3), or four (4).
 - b. Total capacity of all generators in service shall not be less than 500 PPD.
 - c. Minimum required output for a single generator shall be $\frac{1}{4}$ (or lower) of the rated generator capacity.
- 2. The ozone system shall be supplied as a complete, fully integrated and working system by the OSS, including programming of PLCs.
- 3. Within the boundary of skid limits, OSS shall provide piping, supports and wiring as shown on the drawings. Other items within the OSS scope of supply are shown as shipped loose items for installation by the Contractor. All other work outside of OSS scope of supply shall be by the Contractor. OSS shall either coordinate with contractor on required size of interconnecting piping and valves or furnish all piping and valves to be installed by the contractor.

2.04 EQUIPMENT:

A. Liquid Oxygen (LOX) System

1. OSS shall furnish one (1) liquid oxygen (LOX) storage tank(s), two (2) ambient air vaporizers, and valves and instruments as shown on the Drawings. OSS or contractor may supply interconnecting piping. Except where shown as part of a skid assembly, contractor to install all system components and equipment, including concrete pads and anchoring. Equipment shall be fabricated, shop tested and shipped as fully assembled units as indicated on the Drawings.
2. All piping sections where liquid oxygen could become trapped by closing valves shall be protected by pressure relief valves. Where additional pressure relief valves, beyond those shown on the Drawings, are required due to piping layout, Contractor to provide. All liquid oxygen service pressure relief valves to be fitted with piping to discharge to a safe location.

B. Liquid Oxygen Storage Tank

1. Number of tanks provided: 1
2. The liquid oxygen storage tank shall be Vertical doubled-walled cryogenic tank(s) based on the following conditions:
 - a. Gross capacity of tank: 9,000 gallons
 - b. Maximum Allowable Working Pressure: 175 psig
 - c. Design Temperature: +150 to -320°F (+120° Max. for inner vessel)
3. Liquid oxygen storage tank shall be double-walled cryogenic construction. The inner vessel shall be 304 SS, designed, fabricated, tested, inspected and stamped in accordance with Section VIII, Division I of the ASME Code. Testing shall include hydrostatic factory test as required by code. The outer vessel shall be carbon steel vacuum jacket, designed for full vacuum internal to support the inner vessel. Vacuum space shall be insulated for a boil-off rate not to exceed 0.3% of the tank capacity, by weight, per day. Tank shall include mounting base for anchoring to concrete pad. All exterior, exposed tank surfaces to be painted with manufacturer's standard paint.
4. Inner vessel pressure relief shall consist of both automatic primary and secondary relief devices and manual tank vent valves. Outer vessel pressure relief shall consist of an automatic relief device. Tank shall include an economizer system to re-direct gaseous oxygen back into the system, rather than venting to atmosphere.
5. Tank shall be pre-assembled with all related safety devices, appurtenances and equipment for proper operation. A pressure building system and appropriate

pressure regulator shall be provided such that pressure leaving the system is not less than 50 psig.

6. Internal piping and fittings shall be 316 SS welded construction. External piping shall be Type K copper with wrought copper fittings. All valves shall be of bronze construction. Liquid oxygen service valves shall be fitted with extended stems and bonnets and be rated for cryogenic service. The tank shall include a dip tube liquid withdraw system, a vapor return line from the economizer system, level transmitter, pressure transmitter and fill connection. Fill lines shall be fitted with quick connect couplings for tanker truck connection.
7. All applicable hazardous material signage shall be provided with the tank. Contractor shall permanently affix signage as required.

C. Ambient Air Vaporizers

1. Number of vaporizers provided: 2
2. Ambient air vaporizer shall be provided for the liquid oxygen vaporization system including all related safety devices, appurtenances and equipment required for operation. The design of the vaporizer shall be such that the system can continuously deliver oxygen to the ozone generators.
3. Vaporizer shall be an ambient air vaporizer, factory assembled unit complete with bracing, lifting lugs, pressure safety relief valves, necessary internal manifolding, and suitable for outside installation and operation. The materials of construction shall be suitable for design conditions, shall be oxygen compatible, factory cleaned for oxygen service and sealed. Connections shall be NPT or ANSI 150# flange.
4. Vaporizer shall be capable of receiving liquid oxygen from the storage vessel and continuously converting it to gaseous form to supply the ozone system at required system pressure. Further oxygen compression shall not be required.
5. Vaporizers shall be sized to operate in Duty/ Standby at 12 hours cycle time.

D. Trim Heater

1. Number of heaters provided: 1
2. Gaseous oxygen (GOX) trim heater to be electric gas heater. Construction to be stainless steel heat transfer coils cast into an aluminum block. Electric cartridge heaters shall be moisture-sealed and replaceable with included over-temperature protection. Trim heater to be powered by 120 VAC 2000 Watt with all controls and disconnect switch in a weatherproof enclosure. Unit to be provided fully factory wired and assembled.

E. Gaseous Oxygen Manifold

1. Number of manifolds provided: 1
2. Gaseous oxygen (GOX) conditioning manifold to be provided for installation downstream of oxygen feed system and upstream of ozone generator. GOX manifold shall include a GOX Filter with differential pressure gauge and filter bypass line.
3. GOX Filters shall be sized for maximum gas flow required and shall include pull-out style replaceable and cleanable filter cartridge capable of retaining particles greater than 1.0 micron in size with 99% efficiency and particles greater than 0.40 micron in size with 98% efficiency.
4. Redundant self-contained pressure reducing regulating valves shall be provided in parallel to regulate the oxygen pressure entering the ozone generators. The valves shall be sized to cover the full range of gas flows required to meet the design conditions of the ozone system. The valve shall reduce the oxygen gas pressure to 20 psig, or as required by the OSS. Appropriate valves shall be provided for isolation of a single regulator valve while another is being serviced.
5. Additional instrumentation shall include pressure gauge, temperature transmitter and low temperature switch. An appropriate sample tap and isolation valve shall be provided for dewpoint measurement. The maximum dew point shall not exceed -76°F at any time.
6. GOX Manifold shall be constructed of 316 SS piping and fittings. Manifold shall be mounted on painted carbon steel skid frame, including pipe supports, mounting hardware, etc. Piping shall be cleaned and packaged for oxygen service per CGA G-4.1.

F. Compressed Air System

1. If pneumatic valves are required for automatic operation, a centralized compressed air system is available at the plant. OSS shall coordinate with contractor if compressed air is needed for valve operation.

G. Nitrogen Generation System

1. If nitrogen boost is required by the manufacturer to achieve the specified ozone concentration, the OSS shall furnish a complete nitrogen boost compressor system.
2. The nitrogen generation system shall be provided as a skid mounted unit and shall be fully factory tested prior to shipment. Provide valves and instruments as necessary for a complete and functional system.
3. Air compressors
 - a. Compressor shall be air-cooled and 100 percent oil free.

- b. Compressor shall be supplied with an air-intake filter. Filter shall be replaceable element type that has a full life efficiency of 99.2% at 10 microns or larger.
 - c. Compressors shall utilize a check valve located at the compressed air discharge in order to prevent the discharge air from flowing back through the air compressor.
 - d. Compressor motors shall be a four-pole, high efficiency ODP motor.
- 4. Nitrogen Gas Receiver Tank
 - a. Receiver tank shall be vertically oriented to reduce system footprint.
 - b. Receiver tank shall be appropriately sized by the OSS for the gas flows provided.
 - c. Receiver tank shall be ASME stamped and include a manual drain valve.
 - d. Receiver tank shall be supplied with all required valves and instrumentation.
- 5. Nitrogen Separation Membrane
 - a. A membrane separator utilizing a polyimide hollow fiber membrane that provides higher permeability to oxygen than nitrogen to obtain 95-97% pure nitrogen gas shall be installed in the Nitrogen Generation System.
 - b. The membrane separator shall be sized to provide a nitrogen dewpoint of -40°F at the generator outlet at the peak calculated demand.
 - c. Membrane bundles shall be replaced no sooner than 3 years into the system's operational life.
- 6. Water Separator
 - a. A water separator shall be installed upstream of the nitrogen membrane.
- 7. Particulate Filter
 - a. A 1.0 micron filter shall be installed upstream of the nitrogen membrane.
 - b. Local differential pressure indication shall be provided on the filters.
- 8. Coalescing Filter
 - a. A 0.01 micron pre-filter (coalescing) shall be supplied upstream of the nitrogen membrane.
 - b. Local differential pressure indication shall be provided on the filters.

H. Ozone Generator System

1. Number of generators provided: 2 Minimum, 4 Maximum as determined by the OSS to meet the specified output.
2. Ozone generation equipment shall be continuous duty water cooled and as further described below.
3. The generator shall be provided with complete controls, instrumentation, appurtenances and miscellaneous equipment required for a complete ozone generating system using concentrated oxygen.
4. Modular Construction: The ozone generators shall be of modular design featuring an ozone generator enclosure, internal platform that will accommodate multiple fully independent ozone generator units, common internal power distribution system, common data bus, common oxygen supply manifold, common ozone outlet manifold, and common cooling water inlet/outlet manifold. Up to the limitations of the enclosure, each ozone generator enclosure shall be expandable with no modifications to the enclosure other than adding additional ozone generator cells. No modifications to inlet/outlet piping, controls, etc. shall be required.
5. Ozone Platform Enclosure: The ozone platform enclosure complete with all ozone generator cells housed within it shall be rated NEMA 12, or meet NEMA 12 requirements and provide equivalent certification, and UL508A listed or provided with equivalent certification. The enclosure shall be sealed to prevent the exchange of air to the surrounding room. The enclosure shall be supplied with an internal cooler.
6. The enclosure shall have single points of connection to site utilities including: 480VAC, 45kW power in, oxygen inlet, ozone outlet, cooling water inlet / outlet, compressed air and controls / data bus in/out. For 460VAC or 400VAC power supplies an external step down transformer shall be provided. Provide disconnect switch for the equipment.
7. Ozone Generator Cell: Each ozone generator cell shall be capable of completely independent operation and shall consist of a minimum of four (4) ozone production cells connected to a common control board. Ozone generator cells shall be UL508 listed and of completely sealed design and require no field maintenance. Ozone dielectric elements shall consist of non-fouling, monolithic planar ceramic dielectric materials. Glass dielectric materials, or ozone cells that are not of sealed design or require field maintenance shall not be permitted.
8. Ozone Power Supplies: Each ozone generator unit shall have built-in fully independent high-frequency power supply operating at a minimum of 20kHz. External power supply units (PSU) shall not be permitted. Ozone generators that operate below 20kHz shall not be permitted unless they are fully enclosed in a noise limiting enclosure.

9. Ozone Generator Controls: The generator shall be provided with complete controls, instrumentation, panels, appurtenances and miscellaneous equipment required for a complete ozone generating system using oxygen. Automatic operation of the ozone generator shall be controlled through an Allen Bradley Compact Logix programmable logic control (PLC) system mounted inside the ozone platform enclosure. The operator interface shall be Allen Bradley Panel View Plus 7. The operator interface shall be a NEMA Type 12, 13, 4X rated, 15", color LCD touchscreen display with Ethernet communications. In lieu of Allen Bradley, a Schneider Modicon or Magelis controller may be used, meeting the same requirements for enclosure rating, display size, and communications. For a Schneider alternative, provide full capability to integrate with the Allen Bradley Main Ozone Control Panel (MOCP).
 - a. Provide a top-mounted strobe on the main control panel to indicate alarm status when ambient ozone levels (monitored by the ambient ozone sensors) observe the alarm setpoints.
10. Ozone Generator Instrumentation: The generator shall be provided with a minimum of instrumentation consisting of oxygen mass flow meter (inlet), hi-range ozone analyzer (outlet), and cooling water temperature transducers (inlet & outlet).
11. Ozone Generator Isolation Valves: The ozone generator shall be equipped with both manual and automatic isolation and control valves, including: pneumatically actuated oxygen gas valve, manual oxygen isolation valve, pneumatically actuated spring return ozone outlet control valve, manual ozone outlet isolation valve, pneumatically actuated spring return cooling water inlet control valve, and manual cooling water inlet and outlet isolation valves.
12. All equipment, valves, piping, associated appurtenances shall be suitable for ozone in oxygen service.
13. Generator Design Requirements:
 - a. Number of Ozone Generators Required: 2 Minimum, 4 Maximum as determined by the OSS to meet the specified output.
 - b. Total Ozone Generation Capacity considering all generators in service: 500 PPD at 10% O₃ by weight
 - c. Minimum individual ozone generator turndown shall be 4:1 of the rated generator capacity at 10% O₃ by weight.
 - d. Maximum Oxygen Gas Flow Rate to Generator determined by OSS.
 - e. Minimum Ozone Generator Outlet Pressure: 20 psi
 - f. Cooling Water Temperature Rise at rated production capacity: Maximum 10 degrees F.

- g. Maximum Ozone Generator Cooling Water Flow Rate at rated maximum production capacity determined by OSS.
- h. Minimum Cooling Water Supply Pressure: 40 psig unless otherwise provided by the closed loop chiller internal circulation pumps.
- i. Maximum Carrier Gas Rise Across Generator: 17 degrees F
- j. Maximum Inlet Hydrocarbon Concentration : 15 ppm
- k. Maximum Ozone Power Generating Consumption shall be 4.6 kW-hr/pound at a 10% ozone gas concentration at 50 degree F cooling water temperature.
- l. Maximum ozone generating oxygen consumption shall be 10 pounds oxygen per pound of ozone at any ozone production capacity at 50 degree F cooling water temperature.

I. Closed Loop Chilled Water System

- 1. Number of chillers: 2
- 2. The Ozone Generator system shall be cooled by a chemically treated closed loop chilled water system. The chilled water system shall consist of air-cooled chiller(s) with integral circulation pump and other integral associated equipment such as valves, instruments and controls. The chiller system shall be sized as required by the OSS. The OSS shall provide the required type and quantity of coolant required for the initial fill of the closed loop system.
- 3. Site Elevation: 4,633 ft. MSL
- 4. Cooling Capacity: System redundancy is not required and the total cooling capacity of all chillers in service shall be greater than or equal to the cooling capacity required for all ozone generators in service at maximum ozone production.
- 5. Electrical Power: 480V, 11.5kW. Provide disconnect switch.
- 6. Closed loop chiller shall be adequately sized for the system demands to meet the project design conditions. The chiller shall be a package type with integral chilled water pump(s), expansion tank, air and pressure relief valves, isolation valves and instrumentation.
- 7. Structure of the chiller shall be fabricated from galvanized carbon steel panels and painted with polyester powder. A means of lifting the unit will be provided as part of the structure. The compressor compartment must be separated from the condenser section to allow for accessibility when the unit is running.
- 8. Chiller shall be supplied with hermetic scroll compressor(s) complete with protection against overheating and overcurrent and mounted on rubber anti-

vibration dampeners. Unit includes a crankcase heater with automatic insertion to prevent the dilution of the oil by the refrigerant fluid when the compressor(s) is switched off. Refrigerant fluid shall be R410A.

9. The evaporator shall be constructed of finned coils with copper tubes and aluminum fins and a non-ferrous water circuit. The evaporator shall be installed inside the accumulation tank. All materials of construction to be compatible with the installation. Coolant fluid shall be food-grade DowFrost® propylene glycol at a 30% concentration by weight with the balance consisting of distilled water.
10. Unit shall include single phase ON/OFF cooling fan(s) managed by pressure switches or in step mode with pressure transducer.
11. Refrigeration circuit shall consist of the following:
 - a. Refrigerant filter-dryer with hygroscopic molecular sieves
 - b. Refrigerant liquid flow sight glass and moisture control
 - c. Thermostatic expansion valve with external equalization
 - d. High pressure switches
 - e. Low pressure switches.
12. Centrifugal pumps with seals made of silicon carbide with a controlled porosity, graphitized (SiC/SiC/EPDM).
13. Pump nominal head pressure as determined by OSS.
14. A cylindrical storage tank shall be provided with the evaporator installed inside and covered with thermal insulation. The storage tank shall be made of carbon steel and sized to work in closed hydraulic circuits with a maximum pressure of 87 psig. It may also be used in atmospheric hydraulic circuits by the application of the manual filling tank kit. Storage tank will be equipped with a drain valve and bleed valve to vent air during filling of the hydraulic circuit.
15. Chiller shall be provided with an internal hydraulic by-pass between the supply and return of the process fluid. By-pass shall preserve the integrity of the unit and pump in the event shut-off valves are accidentally closed.
16. A conductive type level sensor will be provided for the accumulation tank to stop the unit when level of the process fluid is insufficient.
17. Electronic chiller control with local display shall be integral to the unit to manage chiller operation. Controls shall include main disconnect switch with safety door interlock, automatic circuit breakers for equipment protection, isolation transformer

feeding control circuits, phase monitor, contacts for ON/OFF/REMOTE indication and general alarm output. Electrical cabinet must be in compliance with UL508A.

18. Chiller must be inspected for correct installation of components, refrigeration leaks and electrical safety prior to being shipped by the manufacturer.
19. Chilled process fluid piping shall be insulated

J. Side Stream Injection Skid

1. Ozone gas valve train shall be included on the sidestream injection skid and shall be capable of monitoring and controlling the flow of ozone gas to the injector.
 - a. A suitable backflow prevention device shall be installed to prevent liquid back-up into the gas line. A check valve is not considered to be a suitable means of backflow prevention. A liquid separator shall be provided to remove any liquid that should become backed up into the line. A quick-close valve as specified herein shall be installed to stop flow in the event liquid backs-up into the back-flow prevention device.
 - b. The ozone flow control shall include thermal mass flow measurement, pressure transmitter, modulating flow control valve, pressure sustaining valve to be monitored and controlled by the Ozone System PLC. A means of regulating the back pressure in the system must be provided.
 - c. The ozone gas injection manifold shall be designed to meet the flow requirements of the project across the range of required ozone gas flow rates.
 - d. Provide a level switch or other suitable sensor to the backflow device for automatic indication of liquid intrusion into the backflow device.
2. Sidestream Injection Pumps and Accessories
 - a. Number of pumps: 2 (duty standby) skid mounted.
 - b. The injection pumps shall be variable speed, end suction type centrifugal pumps. Pumps and venturi injectors shall be skid mounted.
 - c. Each pump shall be rated for a minimum flow of 700 gpm at 140 ft TDH or as required by the OSS or Sidestream Injection Manufacturer.
 - d. Pump motors shall be NEMA standard TEFC, inverter duty rated, premium efficiency type.
 - e. Common pump suction header or discharge header (prior to ozone injection) shall feature a magnetic flow meter, included with the skid.

- d. Off-Gas Relative Humidity 100%.

M. Off-gas Ozone Destruct Unit

1. Number of units: 2
2. The Ozone Destruct Unit shall be designed to pull off-gas from the contactor headspace, maintaining a vacuum at a range acceptable to the contactor design, and destroy unused ozone to a level ≤ 0.08 ppmv. The Ozone Destruct Unit is to include pre-heater, catalytic destruct vessel, off-gas blower, vent gas ozone analyzer (integral to the destruct unit or supplied loose for field installation), and associated valves. Unit to be constructed of stainless steel pipe and fittings and shall be mounted on a painted carbon steel skid frame with 150# ANSI flange or NPT connections. The unit shall be sized to maintain vacuum within a pre-defined range in the contactor off-gas.
3. The pre-heater shall be an electric cartridge style installed in the off-gas stream. The pre-heater shall be controlled by the PLC to heat the off-gas going into the catalyst vessel whenever the blower is running. Pre-heater shall be Watlow or approved equal.
4. The catalytic destruct vessel shall include catalyst trays as required to prevent catalyst leaving the vessel as well as removal and replacement of catalyst with minimal disassembly of the unit. Catalyst material shall be manganese-dioxide based Carus Carulite 200 or equal in sufficient quantity to meet design requirements. A differential pressure gauge shall be provided to monitor head loss across the catalyst bed.
5. The off-gas blower shall be a self-contained package including motor and drive unit. The blower shall be cast aluminum construction with internal inlet and exhaust muffling. Motor shall be UL approved and include stainless steel shaft, TEFC enclosure and permanently sealed bearings. External blower connections shall be 150# ANSI flange or NPT. Blower shall be CP series as manufactured by Rotron or approved equal. An expansion joint shall be provided on the inlet and outlet of the blower. Outlet of blower to be piped to exterior and to a minimum height of 11'-0" above ground level by Contractor.
6. Manual ball valves shall be provided at the inlet to the unit for isolation. A manual ball valve shall be provided upstream of the pre-heater to allow atmospheric intake in order to prevent over-vacuum of the contactor. A vent gas ozone analyzer shall be provided on the destruct unit skid to continuously sample the exhaust stream from the blower to verify destruct performance.
7. Junction Box or Control Panel with Disconnect
 - a. The factory assembled destruct unit shall include a junction box or control panel with HMI. All electrical and signal wiring shall be terminated to terminal blocks in the enclosure. Contractor to connect to termination blocks

as shown on associated wiring diagrams. Exterior of the enclosure shall be fitted with an On/Off selector switch for electrical disconnect. The electrical power will be 480V, 1.4 kW. For 460VAC and lower power supplies, an external step down transformer shall be provided.

8. Silencers: If the normal operating conditions of the destruct units exceed a sound intensity of 85 dBA, provide a silencer or sound enclosure on each unit to reduce noise below this level.

N. Off-gas Demister

1. Number of demisters provided: 2
2. Demisters shall be sized to remove entrained moisture in the off-gas stream. Demister pad shall be constructed of 316 stainless steel interwoven strands, installed in a 316 stainless steel housing with 150# flanged connections. Demister sizing shall limit face velocity at the demister to maximum 8.0 fps and maximum pressure drop across the demister of 1.0 inch water column at full design gas flow.
3. The inlet pipe of each demister shall feature a pressure/vacuum transmitter to monitor vacuum pressure and signal an alarm for high vacuum conditions.

O. Ozone Residual Sample Station

1. Sample station may be provided as a packaged system or loose shipped for installation by the contractor.
2. Total number of sampling stations: 4
3. Each sampling station shall have the following components:
 - a. 1 inline and non-reagent dissolved ozone sensor probe / analyzer
 - b. 1 flow indicators to verify flow
 - c. 1 sampling pump with (1) suction isolation valve, (1) discharge isolation valve, and (1) discharge check valve
 - d. 1 manual sample tap and valve on pump discharge piping
 - e. All piping and valves shall be 316 stainless steel.
4. Route sample pump discharge piping back to the ozone basin inlet piping as indicated on the drawings.
5. Sample pump suction pipes shall feature a manifold inside the tank to better accommodate uniform and representative samples as shown on the drawings.

P. Electrical and Controls System

1. Equipment shall be locally controlled and shall be capable of receiving standard digital or analog control signals from the plant central control system. Status and adjustments to the equipment shall be provided locally and from the plant central control system. Instruments shall be provided with mounting hardware as appropriate. Transmitters with digital outputs shall be accurate to within 1 percent. Primary control voltage shall be 120VAC, 60Hz. Controls shall be provided to remotely monitor and adjust ozone production rate, ozone output concentration, liquid chemical delivery rate(s) (if so equipped), oxygen feed, and cooling water feed. Each major component shall have HMI indication to display the power / on / off status and all three-phase motors shall have a non-resettable HMI elapsed time meter with ability to record operable hours from 0 to 99,999.
2. Ozone Control System
 - a. The ozone control system shall be interfaced with the plant central control system. Changes to the ozone generator equipment operating conditions shall be accomplished locally or from the master control panel. The power, control and instrumentation system provided shall be as specified or as recommended by the ozone generator manufacturer for safe operation and supervision of the ozone generator and related gas feed equipment. Schematics and interconnecting wiring diagrams shall be provided for power, control, and instrumentation circuits. Control power transformers, relays, adjustable timers, auxiliary contacts, switches, or additional equipment to interconnect the generator to other auxiliary equipment and master control panel, and control circuits as shown on schematic or instrument control drawings shall be provided. A hard-wired emergency stop button shall be provided at the local generator control panel. The ozone generator shall be protected from power surges, and variations in power supplied to the equipment.
3. Master Control Panel (PLC-ZG)
 - a. Electrical power 120V, 5kW
 - b. PLC: Allen-Bradley Compact Logix
 - c. Operator Interface Terminal (OIT): Allen Bradley Panel View Plus 7
 - d. Communications: Ethernet port
 - e. Control panel shall meet specifications 40 9441, 40 9442, 40 9443, 40 9513, 40 9553, and electrical sheet I-03.
4. Alarms and Interlocks
 - a. Alarms and interlocks shall be provided to ensure proper operation of the ozone generation system and sequenced shutdown in the event of potentially unsafe or improper conditions that may arise. The following paragraphs list alarms that (as a minimum) shall be monitored at the central control point, or

that will initiate shutdown of the appropriate ozone generation system components.

b. Ozone Generator Enclosure or Master Ozone Control Panel

- (1) High dew point in gas feed to ozone generator
- (2) Over current to the power supply unit (PSU)
- (3) Over voltage to the PSU, rectifier, and inverter
- (4) Over frequency protection
- (5) Generator enclosure high temperature shut down, monitored from inside the enclosure or from cooling water supply temperature transmitter.
- (6) High inlet gas temperature
- (7) High outlet ozone gas temperature
- (8) High inlet cooling water temperature
- (9) High gas pressure to the generator
- (10) Insufficient gas flow to the generator
- (11) High moisture / humidity level monitored from inside the control cabinet enclosure or from a transmitter installed in the room.
- (12) High / low ozone concentration
- (13) Major equipment component failure such as over current, over voltage, over frequency, high cooling water temperature or other condition that could damage the equipment or result in effluent non-compliance shall initiate system alarms, followed by plant shutdown, if not acknowledged.

c. Oxygen Feed System

- (1) High pressure downstream of reducing valves
- (2) Oxygen ambient monitor to be installed in the ozone room for detection of high ambient air oxygen levels
 - (a) Comply with requirements specified in Section 40 76 00.
- (3) Major equipment component failure, such as air preparation failure or other conditions that could damage the air feed or ozone equipment, or

result in effluent non-compliance shall initiate system, followed by plant shutdown, if not acknowledged.

d. Ozone Destruct System

- (1) High / low vacuum at contact chamber
- (2) High ozone in destruct unit exhaust gas
- (3) High ozone concentration in off gas from contactor
- (4) Destruct system failure
- (5) Health and safety ambient ozone level non-compliance shall initiate ozone system alarm and shutdown, followed by overall plant shutdown, if alarm is not acknowledged (high ambient ozone levels will not shutdown the ozone destruct system concurrently with other processes).

e. Cooling Water System

- (1) Cooling systems failure
- (2) High water temperature
- (3) No / low cooling water flow
- (4) Pump failure
- (5) Major equipment component failure such as no/low cooling water flow, pump failure or other condition that could damage the gas feed, ozone equipment or result in effluent non-compliance shall initiate ozone generator, followed by plant system shutdown, if not acknowledged.

f. Ambient Air Ozone Detector: OSS shall supply an ambient air ozone gas detector to be installed by the contractor in the Ozone Room. Detection of a residual ozone concentration above the setpoint shall immediately shut down the ozone generators and isolate the gaseous oxygen supply by closing emergency shut-off valve.

- (1) Comply with requirements specified in Section 40 76 00.

5. Analytical Instruments

- a. Comply with the requirements specified in Division 40.
- b. OSS must supply all analytical instruments as indicated on the drawings and as required for a full functional and operational system. OSS may select instrument manufacturer and warrant instruments as part of the package. Instruments included in the OSS scope of supply must include the following:

- (1) Level sensors / transmitters
- (2) Pressure sensors / transmitters
- (3) Differential pressure sensor / transmitters
- (4) Temperature sensors / transmitters
- (5) Dew Point Analyzers / transmitters
- (6) Flow meters / transmitters
- (7) Ambient oxygen sensors / transmitters
- (8) Ambient ozone sensors / transmitters
- (9) In-solution ozone analyzers / transmitters

2.05 SHOP TESTING:

- A. OSS shall conduct their standard factory testing in the OSS shop prior to shipment of equipment to job site. Equipment shall be given manufacturer's standard quality control inspections and tests to ensure the quality of materials used in the manufacture of the equipment and workmanship conform to the specified requirements. The OSS must prepare and submit a final report certifying the test results.

PART 3 - EXECUTION

3.01 EXAMINATION:

- A. Verify that all components have been constructed in accordance with approved shop drawings and to the tolerances required by the equipment manufacturer.

3.02 INSTALLATION

- A. OSS shall provide instructions and recommendations to Contractor for installation of ozone system components. All ozone equipment shall be installed by the Contractor in strict compliance with the instructions and recommendations of the OSS. Connections on oxygen-cleaned equipment shall remain factory sealed until ready for connection. All equipment that has been oxygen cleaned prior to shipment shall be delivered with sealed connections and a label indicating that equipment has been cleaned and should not be un-sealed until ready for installation. Any equipment that is un-sealed before the time of installation must be properly flushed and / or cleaned and re-sealed by the Contractor per "Cleaning for Ozone / Oxygen Service".
- B. OSS shall provide Contractor with supplier's instructions for installation of all skidded and field installed components. OSS shall provide Contractor with the quality requirements for initial fill of the closed-loop side of the cooling water system. Any

finished surface damaged during installation must be touched-up by the Contractor per OSS recommendations. Contractor shall be responsible for providing and installing all field wiring, except as specified otherwise.

3.03 SERVICE:

- A. The equipment manufacturer shall furnish the services of a factory trained representative for a no less than 4 trips and 20 eight hour days at the jobsite to inspect the installing contractor's equipment installation, supervise the initial operation of the equipment, instruct the plant operating personnel in proper operation and maintenance, and provide process assistance.
- B. If additional service is required due to the mechanisms not being fully operational, at the time of service requested by the contractor, the additional service days will be at no expense to the owner.

3.04 FIELD TESTING:

- A. All liquid oxygen (LOX) required for the start-up, functional testing and performance testing will be provided by the Owner. Owner will provide all required cooling water and electrical power to conduct all ozone system testing. Prior to testing the ozone generators, all associated process and safety monitoring equipment and instrumentation including ambient leak detection, process piping, dissolution system, contactors and destruct system shall be completed, tested and functional.
- B. Ozone destruct units shall be installed and working prior to testing. Sufficient charges of ozone destruct catalyst shall be installed prior to testing to ensure the specified ozone destruction. Ozone shall not be released into process piping until piping installation is completed and flowing water is present.
- C. After each ozone generator unit has been completely installed, initially inspected, and operationally tested, OSS standard functional acceptance tests shall be performed by OSS representative. Functional tests shall cover full specified operating range for the ozone generator. Test each generator to verify equipment operational characteristics are in accordance with the conditions specified in this Section. The OSS shall conduct functional testing in the presence of the Owner or Owner's representative.
- D. After completion of functional testing, mass transfer efficiency testing with ozone shall be conducted to verify the specified MTE is being achieved. All temporary barriers, equipment, tools, etc. shall be removed from the ozone contact basin. Ozone destruct units and ozone generation systems shall be operational prior to performance testing. Ozone contact basin shall be isolated. Sodium Bisulfite shall be applied at the end of the contact basin to quench any remaining ozone. OSS shall conduct performance testing of the ozone dissolution system in the presence of the Owner and / or Engineer. Ozone sidestream dissolution system supplier representative shall be on-site during mass transfer efficiency testing.

Mass Transfer Efficiency shall be defined as:

$$\text{MTE} = \frac{(\text{O}_3 \text{ Concentration In} \times \text{Gas Volume In}) - (\text{O}_3 \text{ Concentration Out} \times \text{Gas Volume Out})}{(\text{O}_3 \text{ Concentration In} \times \text{Gas Volume In})} \times 100\%$$

If the equipment does not satisfy the specified performance criteria corrective measures shall be taken by the manufacturer and OSS to meet specified performance at no additional cost to the Owner.

E. Generator Performance Tests

1. Prior to testing, the ozone generators shall be dried by purging dry oxygen gas through the ozone generators under the direction of the OSS. Test each ozone generator and electrical power supply unit under actual operating conditions to determine that the operation is satisfactory and power consumption and ozone production characteristics are completely developed. Two (2) types of tests shall be conducted as described herein.
2. At least six (6) consecutive readings at each power loading or production level shall be taken and recorded at 15-minute intervals for each ozone generator, after steady-state ozone production conditions are attained.
3. Conduct performance testing of each ozone generator over range of outputs determined by the OSS. Average performance for each ozone generator at these evenly weighted production rates shall not exceed the values indicated in the Ozone Generator Section.
4. In addition to performance testing, conduct additional test for at least 15-minute intervals each for minimum, average and maximum design ozone concentration values to determine specific energy (kWh/lb) at these ozone concentrations. Submit testing results.
5. OSS shall supply portable calibrated power meter and ozone concentration analyzer with factory certified calibration to verify accuracy of generator-mounted high concentration ozone analyzer. The OSS will verify key instruments used for performance testing including thermal mass flow meters, power supply power meters and gas phase ozone concentration analyzers.
6. For each generator, the test data shall indicate as a minimum, the time, oxygen flow rate, inlet oxygen pressure and temperature, ozone-in-oxygen concentration, ozone production, Power Supply Unit (PSU) input power, power factor, specific energy, cooling water flow rate and cooling water inlet and outlet temperatures.
7. If the equipment does not satisfy the specified performance criteria or operational values as certified with the Bid, corrective measures shall be taken by the Contractor and OSS to meet specified performance at no additional cost to the Owner.

3.05 START UP:

- A. A field service technician or start-up engineer of the OSS shall commission the ozone generation equipment. The field service technician shall certify that all equipment is properly installed and that the plant operators have been trained on proper operation and maintenance procedures. The Contractor is required to properly fill out a pre-startup checklist before OSS representative arrives to site.
- B. A field service technician or start-up engineer of the Ozone Sidestream Dissolution System shall commission the ozone dissolution equipment. The field service technician shall certify that all equipment is properly installed and that the plant operators have been trained on proper operation and maintenance procedures. The Contractor is required to properly fill out a pre-startup checklist before Ozone Sidestream Dissolution representative arrives to site.
- C. The cost of all inspection, start-up, testing, adjustment, calibration and instruction work performed by said factory representatives shall be borne by the OSS. The Owner shall pay for costs of power, water, LOX and other required utilities.

3.06 TRAINING:

- A. As part of their service responsibilities, the OSS shall provide training in the operation and maintenance of the ozone system, including all components provided under this contract. Training shall consist of both classroom and hands-on sessions conducted at a time and location acceptable to the Owner. The OSS shall designate a person responsible for scheduling and coordinating all training.
- B. The OSS representative shall provide detailed system training including, but not limited to:
 - 1. Safety Precautions and Emergency Procedures
 - 2. System Operation
 - 3. Understanding of loop operation (i.e. adjusting process variable set points, Local and Remote control, alarm acknowledgement and resetting)
 - 4. Component performance requirements
 - 5. Component functions, operation, maintenance, troubleshooting, replacement and calibration procedures.
- C. Classroom training shall be conducted during regular work hours during a single shift on weekdays at a location to be designated by the Owner. Hands-on training may be conducted during and as part of the start-up. Training shall be split into equal morning and afternoon sessions to accommodate employee's schedules. Copies of all materials used for training shall be provided. The specified manufacturer's services and the OSS

representative shall be coordinated and furnished for post start-up training of the Owner's personnel.

- D. The ozone manufacturer must schedule an agreeable time for the visit to ensure that facilities personnel will have ample training time. The manufacturer may include classroom training during each visit to provide ongoing education and communicate equipment updates. Each maintenance procedure shall be performed first by the manufacturer's representative with the facilities personnel observing. The facilities personnel will then perform the same task under the supervision of the manufacturer's representative.

3.07 PROTECTION:

- A. All equipment, piping, valves, instruments and associated appurtenances to be used with oxygen/ ozone service shall be properly cleaned, labeled as clean, sealed and protected for oxygen service prior to shipment to site. Contractor shall use caution in storage, handling and installation of such items to avoid compromising oxygen cleaning. Contractor shall field clean all piping, fittings, equipment, etc. that come into contact with oxygen and/or ozone liquid or gas. All cleaning must comply with the latest revision of CGA G-4.1. Piping requiring this cleaning is as follows:

1. All liquid oxygen piping
2. All gaseous oxygen piping
3. All ozone gas piping between generators and eductors
4. All liquid ozone solution piping between eductors and basins
5. All sampling piping including supply and return lines
6. All air draw-off piping between basins and destruct units
7. All basin vent piping

3.08 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 46 33 44

PERISTALTIC METERING PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section includes furnishing and installing adjustable speed peristaltic chemical feed pumps where shown on the Drawings, specified, and listed in Table attached with this specification section. All chemical feed pumps shall be furnished by the manufacturer on a pre-assembled panel suitable for wall mounting, which contains all equipment and materials specified and required for operation and control of the pumps. All pumps shall be suitable for the indicated chemical and application. Installation shall include all accessories as may be required and not mounted on the panel, such as pump tubing, translucent HDPE tubing, tubing fittings, pressure relief valves, drum/tote siphon tubes, and appropriate tank/drum/tote seals. All accessories shall be made of material suitable for the chemical being fed.
- B. This section also includes furnishing one peristaltic pump for conveying water to an analytical instrument. This pump is to be mounted on a shelf as indicated on the drawings, and does not require a pre-assembled panel with accessories.

1.02 REFERENCES:

- A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including but not limited to Division 01 General Requirements.

1.03 1.3 SUBMITTALS:

- A. Submit the following in accordance with Section 01 33 00:
 - 1. Certified shop drawings.
 - 2. Characteristic performance curve showing flow rate as a function of RPM and pressure.
 - 3. Dimensional drawings.
 - 4. Operating, maintenance, programming, and wiring instructions
 - 5. P/10 ratio calculation.

1.04 SPARE PARTS:

- A. Comply with the requirements specified in Section 01 61 00.

- B. Spare Head Assemblies: Provide one (1) spare pump head assembly for each size of chemical feed pump provided.
- C. Provide one (1) spare tube for every chemical pump supplied with the project.

1.05 QUALITY ASSURANCE:

- A. Comply with the requirements specified in Section 01 43 00.
- B. Pumps shall, at a minimum, meet the following design requirements.
 - 1. Pumps shall be designed so that they do not to exceed a specified P/10 ratio (theoretical maximum number of occlusions per 10 gallons pumped) so as to maximize pump efficiency and minimize tube fatigue, performance, and accuracy. Pumps exceeding the specified P/10 ratio will not be considered suitable for the duty condition. The following criteria are set to maintain the P/10 ratio below the maximum for the tube size specified:
 - a. Maximum two compressing rollers for two compressions per revolution.
 - b. Tube wall thickness of 2.4 mm and material specified
 - c. Large diameter spring-loaded roller set for 2.4 mm wall thickness tubing
 - d. Max base drive speed of 220 RPM for 2.4 mm wall thickness tubing.
 - e. Track geometry of not less than 180 degrees and rotor geometry with rollers 180 degrees apart.
- C. P/10 ratio shall not exceed the following per tube size:

Tube Bore & Wall	P/10 ratio	
1.6mm	x 2.4mm	181,820
3,2mm	x 2.4mm	45,460
4.8mm	x 2.4mm	20,840
6.4mm	x 2.4mm	11,570
8.0mm	x 2.4mm	7,170
9.6mm	x 2.4mm	4,960

- D. Drive and pump heads shall be 24-hr continuous duty rated and have a three-year manufacturer's warranty from date of startup.
- E. Pumps shall be the manufacturer's standard product. Manufacturers of tubing pumps shall have at least 20 operating installations in municipally owned water or wastewater treatment plants over a period of at least five years in the same application and size specified.

- F. Pumps shall be manufactured under ISO 9001.
- G. Pumps shall meet all applicable CE and CETL US standards per UL610101A

1.06 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 01 66 10 and as specified herein.
- B. Delivery, storage, and handling shall meet the requirements of manufacturer/supplier in general and the following specifically:
 - 1. Shipping: Ship pump and drive assemblies complete. Ship tubing separately packed in a continuous length. Required length for installation shall be cut by the Contractor, with the remaining tubing stored for spare replacement.
 - 2. Pack all spare parts in containers bearing labels clearly designating contents and the specific equipment for which they are intended.
 - 3. Deliver spare parts at the same time as equipment.
- C. Receiving
 - 1. Contractor shall inspect and inventory items upon delivery to site.
 - 2. Contractor shall store and safeguard equipment, material, instructions, and spare parts in accordance with manufacturer's written instructions.

PART 2 - PRODUCTS

2.01 DESCRIPTION

- A. Pumps shall be positive displacement peristaltic type complete with spring-loaded pump head, self-contained adjustable speed drive, and flexible extruded tube as specified.
- B. Chemical feed pumps shall be capable of sending and receiving 4-20 mA signal for speed control.
- C. Peristaltic pumping action shall be created by the compression of a flexible tube between the pump head rollers and track, induced forward fluid displacement within the tube by the rotation of the pump rotor, and subsequent vacuum-creating restitution of the tube.
- D. Pumps shall be dry self-priming, and be capable of being run dry without damaging effects to pump or tube. Pump shall have a maximum suction lift capability of up to 30 feet vertical water column. Maximum pressure discharge rating shall be in excess of the Max psi listed in Table 1. Pump shall not use check valves or diaphragms and shall not require dynamic seals in contact with the pumped fluid. Process fluid shall be contained within pump tubing and shall not directly contact any rotary or metallic components.

- E. Flow shall be in the direction of the rotor rotation, which can be reversed and shall be proportional to rotor speed.
- F. The manufacturer shall provide pre-assembled chemical feed panels which can be mounted directly on the wall or Unistrut type frame system.

2.02 PUMP MANUFACTURERS:

- A. Watson Marlow.
- B. Blue-White.
- C. Prominent Fluid Controls.

2.03 PUMP CONSTRUCTION:

A. Pump Head

1. Pump head shall consist of a fixed track, a hinged guard door, two spring-loaded tube clamp mechanisms, and spring-loaded roller rotor assembly. Pump tubing shall be in contact with the inside diameter of the track through an angle of 180 degrees and be held in place on the suction and discharge by a spring loaded self-adjusting clamp mechanism. At all times, one roller shall be fully engaged with the tubing providing complete compression and preventing back flow or siphoning.

a. Pump Head Assembly

- (1) Provide high corrosion/impact materials as specified.

- (a) Track Construction: polyphenylene sulfide (PPS)
- (b) Guard Construction: hinged impact-resistant polycarbonate breakaway guard, tool un-lockable for operator safety.
- (c) Rotor Construction: polyphenylene sulfide (PPS)

- b. Tube Retainer Mechanism: Provide two spring-loaded adjustable tube retainer mechanism to secure the tubing at the entry and exit points of the pump head

c. Rotor Assembly:

- (1) Provide rotor assembly that ensures gradual tube occlusion and compensates for tube tolerance:
 - (a) Twin spring-loaded roller arms located 180 degrees apart, each fitted with stainless steel helical springs and compressing roller for occlusion of the tube twice per rotor revolution

(1) Compressing Rollers: 316SS with low friction stainless steel bearings and PTFE seals, minimum diameter of 18 mm.

(a) Provide non-compressing guide rollers constructed of corrosion resistant Nylatron.

2. Clutch: Equip rotor with a central handgrip hub and manually activated clutch to disengage the rotor from the drive for manual rotor rotation during tube loading. Clutch shall automatically reengage rotor to gearbox upon one complete revolution.
3. Mounting: To prevent slip, the rotor assembly shall be axially secured to the dogged output shaft of the gearmotor via a slotted collet and central retaining screw.
4. Pump heads requiring disassembly or special tools for tube changing are not acceptable.

B. Pump Tubing

1. Pump head shall accept tubing sizes 1.6mm, 3.2mm, 4.8mm, 6.4mm, 8.0mm and 9.6mm with 2.4mm wall thickness and materials including, Marprene. Pumps that require tools for adjustment or changing pump heads to accept different tubing materials or sizes are not acceptable.
2. Pump tubing shall be constructed of Marprene II, a thermoplastic elastomer with 64 Shore A durometer and minimum 2.4mm wall thickness. If required for chemical compatibility, pump manufacturer shall recommend an alternate tubing material.

C. Drive

1. Rating: Continuous 24 hour operation, 40 deg C ambient.
2. Supply: 110-120V 60 Hz, 1-Phase. Supply nine-foot minimum length power cords with standard 115V three-prong lug.
3. Max drive power consumption: 135VA.
4. Enclosure: NEMA 4X
5. Housing: Pressure cast aluminum with exterior grade corrosion resistant polyester powder coat. Uncoated housings are not acceptable.
6. Drive motor- brushless DC motor with integral gearbox and tachometer feedback.
 - a. Speed Control Range of 2200:1 from 0.1 to 220 rpm +/- 0.1 rpm throughout the range.
 - b. Closed loop microprocessor controlled drive with pulse width modulation at speeds above 35 rpm and synchronous mode with magnetic field rotation control below 35 rpm

- c. Circuitry complete with temperature and load compensation and protection.
- 7. Mounting: Drive shall be self-supporting and shall not require anchoring.
- D. Chemical Feed Pump Control
 - 1. Supply auto control features to meet the following minimum functionality requirements. Pumps not meeting this minimum functionality will not be accepted.
 - a. Remote Control Inputs
 - (1) Speed Control: Analog 4-20mA or 0-10VDC, with input signal trimmable and speed scalable over any part of the drive speed range.
 - (2) Start/Stop Control: via 5V TTL, 24V industrial logic, or dry contact-Configurable command sense allowing open to equal run or open to equal stopped. Configurable to be a keypad start/stop override in Manual mode.
 - (3) Forward/Reverse Control: via 5V TTL, 24V industrial logic, or dry contact.
 - (4) Auto/Man Mode Control: via 5V TTL, 24V industrial logic, or dry contact.
 - (5) Leak Detector Run/Stop Control:
 - b. Status Outputs
 - (1) Four relay contacts rated for 30 VDC with maximum load of 30W, NO or NC software configurable to indicate the following:
 - (a) Running/Stopped status.
 - (b) Forward/Reverse status.
 - (c) Auto/Manual status.
 - (d) General Alarm status.
 - (e) Leak Detected status.
 - (2) Speed output – Analog 0-10 VDC or 5V Square Wave Frequency output
 - (a) Termination: supply screw down terminals suitable for up to 18 AWG field wire and accessible through four glanded cable entry points on the pump.

2.04 ACCESSORIES:

- A. Provide a section of translucent tubing at the chemical discharge locations to visually observe chemical being fed to the injection point.
- B. Pressure Relief Valves:
 - 1. An in-line, adjustable-pressure, diaphragm-type pressure relief valve, constructed of materials compatible with chemical to be used, shall be provided with each pump. Pressure relief valve shall be capable of being adjusted.
- C. Anti-Siphon Valves:
 - 1. Provide back pressure regulating anti-siphon valve(s) at each discharge pipe of the chemical feed pump panel. Valves shall be of PVC or CPVC construction, and having Hypalon or Teflon diaphragms, suitable for the chemical being pumped, to protect upper works of valve from process fluid. Provide spring opposed diaphragms with loading pressures adjustable by means of screw in top works. Field-adjust valves to settings required of the system. Setting to be minimum pressure to occur upstream of the valve, as installed in system, while pump is operating.
- D. Calibration Column:
 - 1. A clear PVC calibration column shall be provided with each pump. The column shall be sized to provide at least 2 minutes draw down at maximum pump capacity. The calibration column shall be located on the chemical feed pump panel and piped such that chemical is drawn from the calibration column (i.e. draw down calibration). The calibration column shall be vented to the upper edge of the chemical feed pump panel as shown on the process pump schematic to allow for chemical filling and withdraw without creating a vacuum or pressurized calibration column.
- E. Discharge Gauge with Diaphragm Seal
 - 1. A glycerin-filled pressure gauge to indicate pump discharge pressure. Pressure gauges shall cover the full range of the chemical feed pump discharge pressure.
- F. Injection Quill/Nozzle
 - 1. For each injection point, provide an injection quill/nozzle assembly that is removable without dewatering the process line. CPVC body check valve shall be the spring-loaded ball check type. Manufacturer: Saf-T-Flo, or equal. Unions shall be provided for easy removal.
- G. Dilution Water Panel

1. Dilution water panel may be integrated with the metering pump skid or provided as a standalone wall mountable unit, constructed of polypropylene, and include the piping, valves and accessories shown.
2. Rotameters shall have a 10-inch scale. The feed range shall be 10:1 with a V-notch control system capable of maintaining the set feed rate to within 2 percent of the indicated flow. Provide direct read flow scale.
3. Static Mixers: Mixers shall be designed for efficient turbulent-flow mixing at low pressure drop and be suitable for admixing specified chemical. Mixing elements shall consist of a series of polypropylene baffles, and mounted in a clear PVC or CPVC housing with FNPT ends.
 - a. Koflo Corporation, Omega FMX7200 series or equal

2.05 PUMP SCHEDULE:

- A. Values listed as “typical service flow” are the anticipated ranges of pumped chemical flow. Manufacturer shall select a pump from their standard line which best suits the range listed. Minimum and maximum pump ranges shall be beyond those listed.
- B. Sodium Bisulfite; 38%, 1.32 S.G.
 1. Ozone Quench
 - a. Number of pumps: 3
 - b. Typical service flow: 0.1 to 6 gph
 - c. Backpressure: 50 psi
 2. CIP Waste de-chlorination
 - a. Number of pumps: 2
 - b. Typical service flow: 1 to 30 gph
 - c. Backpressure: < 40 psi
- C. Aluminum Chlorohydrate; 38%, 1.35 S.G.
 1. Number of pumps: 3
 2. Typical service flow of each pump: 1 to 30 gph
 3. Backpressure: 50 psi

2.06 PANEL CONSTRUCTION:

- A. Chemical pump and dilution water panel assemblies shall be provided on a pre-plumbed FRP or polypropylene panel as indicated on the drawings which can be attached directly to the wall or a unistrut frame.
- B. Each chemical pump panel shall contain the following:
 - 1. Shelves, each suitable for mounting a pump.
 - 2. All piping, valves, and connections to suction and discharge piping / tubing as shown on the drawings.
 - 3. Peristaltic metering pumps as described above.
 - 4. A common calibration column with appropriate isolation valves and vent. Calibration column shall be piped such that it can fill via the discharge of a pump and be capable of operating in “draw from column” mode.
 - 5. Discharge pressure gauges for each pump with a diaphragm back and isolation valve.
 - 6. Pressure relief valve with discharge connection.
 - 7. Flow indicators (sight glass) where indicated.
 - 8. The panel shall be plumbed such that each pump has its own designated suction pipe and can be connected to flexible suction tubing.
- C. Each dilution water panel shall contain the following:
 - 1. Adjustable pressure regulator factory set to 50 psi on the incoming water supply.
 - 2. Rotameter to visually observe water flow.
 - 3. Chemical injection port downstream of rotameter.
 - 4. Static mixer downstream of chemical injection port.
 - 5. Pressure gauge with diaphragm seal.
 - 6. Associated piping and isolation valves. Electrically actuated isolation valve to control water supply is by others.
- D. The panel layouts have been custom designed for this project for each application and must meet the requirements of functionality and maximum sizes. Detailed layouts of each panel are shown on the drawings and the supplier shall mimic the general design as close as possible. “Standard” panels provided by a manufacturer will not be acceptable unless they fully comply with the functionality and size of the designed panels.

E. If selected manufacturer is unable to construct a panel meeting the design requirements, the Contractor must construct the panel

F. Chemical Pump Panel Schedule

1. Type 1

a. Function: 2-Pump, 1-Discharge Panel

b. Maximum panel width: 48 inches

c. Number of panels provided: 1

d. Applications:

(1) Sodium Bisulfite Panel #1 (CIP waste de-chlorination)

2. Type 2

a. Function: 3-Pump, 2-Discharge

b. Maximum panel width: 72 inches

c. Number of panels provided: 2

d. Application:

(1) Aluminum Chlorohydrate

(2) Sodium Bisulfite Panel #2 (Ozone Quench)

G. Dilution Water Panel Schedule

1. Number of panels provided: 2

2. Application:

a. Sodium bisulfite – feed to clearwell cell 1

b. Sodium bisulfite – feed to clearwell cell 2

PART 3 - EXECUTION

3.01 INSTALLATION

A. Contractor shall install items as specified and as shown on the Drawings in accordance with manufacturer's printed instructions.

- B. Contractor shall supply all accessories needed to connect tubing to pumps and process injection points for a complete and functioning system. This may include, but is not limited to, compression fittings, stainless steel hose claps, hose barbs, and injection quills.
- C. Contractor shall supply shielded signal wiring for the required remote input and output to the connectors.

3.02 TESTING:

- A. All chemical feed piping shall be purged of air and completely filled with clean, dechlorinated water prior to the system tests.
- B. Wet test the entire skid with water to 1.5 times its design operating pressure.
- C. Testing of the chemical metering pump equipment shall be performed in conjunction with the chemical storage tank hydrotest. Perform initial calibration column tests using clean water to verifying the approximate pump accuracy and loop tuning.
- D. At the completion of the system test, all chemical feed lines shall be completely drained of water and dried.
- E. Following draining and drying, the chemical feed pipes shall be filled with their respective chemicals and purged of air.

3.03 MANUFACTURER'S SERVICES:

- A. Conform to the requirements of the manufacturer's field services paragraph 1.5 of the Quality Control Section. Provide a minimum of 24 hours on site performing these services in no less than two separate trips. Additional time required to perform these services shall be at no additional cost to the Owner. The Owner shall be credited for the unused portion of startup services.
- B. Startup services and training of Owner's personnel shall be at such times as requested by the Owner.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 46 61 33

ULTRAFILTRATION MEMBRANE SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Original Equipment Manufacturer or Supplier (OEM) shall furnish the following equipment as specified herein:
 - 1. Thirteen (13) Ultrafiltration (UF) pre-assembled skids complete with epoxy coated steel frame, UF membranes, face and interconnecting piping within skid boundaries, pneumatic control valves, manual valves, analytical instruments, local control panel, and ancillary equipment for a complete and operable system.
 - 2. Two (2) complete UF clean-in-place (CIP) systems including polyethylene tanks, heaters, feed pumps, face and interconnecting piping, pneumatic control valves, manual valves, analytical instruments, local control panel and ancillary equipment for a complete and operable system.
 - 3. Compressed air system including three (3) rotary screw air compressors, two (2) refrigerated air driers, and two (2) vertical air receivers with ancillary gauges, instruments, valves, and accessories for a complete and operable systems.
 - 4. Three (3) horizontal end suction type pumps to perform UF backwashing. Backwash tank, piping, valves, and electrical appearances to be provided by the Contractor.
 - 5. Master membrane system control panel integrated with the overall plant SCADA system for control, monitoring and communication with all UF skids, cleaning system, UF feed pumps (pumps by others), and the balance of the water treatment plant.
- B. The OEM shall provide complete integration and control system programming for monitoring and control of the UF skid system, air system, UF CIP system, and ancillary UF equipment. Provide all necessary control panels, HMIs, I/O racks, software, and other hardware for a complete and functional system.
- C. All OEM equipment provided in this specification, along with interconnecting piping between skids and electrical / control connections will be installed by others. Anchor bolts and mounting hardware to be provided and installed by the Contractor. The OEM shall provide all necessary calculations for anchor bolt design and sizing to facilitate installation of membrane equipment.
- D. The OEM shall provide complete system commissioning including system functionality and I/O checkouts, onsite startup, testing, and operator training for all systems provided.

1.02 REFERENCES

- A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to Division 01 General Requirements.
- B. Refer to Division 26 specifications for Electrical System requirements including wire and cabling, motors, motor control centers, and related components.
- C. Refer to Division 40 specifications for Control System Requirements including control panel hardware, software, control descriptions, network switches, and related components.
- D. Refer to Section 40 23 19.05 for Process Piping and Appurtenances requirements.
- E. Refer to Section 40 23 13.01 for Process Valves and Appurtenances requirements, including pneumatic actuators.

1.03 SUBMITTALS

- A. Comply with the requirements specified in Section 01 33 00.
- B. All submittals shall conform completely to the requirements of the Contract Documents.
- C. Submit shop drawings in 2D and 3D (where applicable) for the equipment to be furnished.
- D. Provide product data including but not limited to valves, actuators, piping, fittings, UF membrane elements, tanks, pumps, heaters, analytical instrumentation, controls, and electrical components.
- E. Wiring plan, wiring diagram, control panel layout, and other relevant information.
- F. Assembly and installation drawings including arrangement, layout, and dimensions of all components including the control panel and piping connections.
- G. Printed instructions for the handling, delivery, storage, and installation of the components.
- H. The OEM shall prepare a comprehensive operation and maintenance (O&M) manual for the system specified as part of this Contract. The manual shall include information on the operation and maintenance of the individual components of the system and the overall package.
 - 1. Maintenance summary forms
 - 2. Vendor O&M data and manuals
 - 3. Pre-operational procedures
 - 4. Controls documentation
 - 5. Operating procedures

6. System maintenance procedures
7. Drawings and diagrams
8. Factory quality control reports
9. Field quality control reports

1.04 SPARE PARTS

- A. Comply with the requirements specified in Section 01 61 00.
- B. UF System
 1. Provide any special tools required for disassembly and removal of a UF module. This shall include, but not be limited to, a mechanical module removal device with the following features:
 - a. Manual operation with hydraulic assist
 - b. Telescopic and rotatable attachment arm with straps to hold module in place
 - c. Lockable rolling caster with brake.
 - d. Manufacturer: Piedmont FiberMove™ or equal.
 2. Provide UF membrane pinning equipment.
 3. Provide one complete seal repair kit for the CIP pumps.
 4. Provide one complete seal repair kit for the backwash pumps.

1.05 QUALITY ASSURANCE

- A. Comply with the requirements specified in Section 01 43 00.
- B. The skid components shall be manufactured from all new materials and equipment.
- C. The Owner or Engineer shall be provided access at any time to inspect or observe all equipment prior to shipment to the site.

1.06 DELIVERY STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 10 and as specified herein.
- B. The OEM will fabricate or furnish and deliver all components of the equipment specified herein to the site. All components shall be properly crated and stored at the job site until ready for installation. All components shall be kept clean, dry, and protected from

freezing. OEM is responsible for shrink wrapping equipment with 6 mil plastic prior to shipping.

1.07 WARRANTY

- A. Provide a written warranty stating that the system and all equipment provided is free of defects.
- B. All components of the UF skid, CIP system, air system, pumps, and ancillary components furnished by the OEM shall be warranted for a period of 1 year.
- C. The UF membranes shall have a pro-rated warranty for an additional 6 years (7 years total) as follows:
 - 1. Years 1 and 2: Manufacturer to cover 100% of replacement cost
 - 2. Year 3: Manufacturer to cover 80% of replacement cost.
 - 3. Year 4: Manufacturer to cover 65% of replacement cost.
 - 4. Year 5: Manufacturer to cover 50% of replacement cost.
 - 5. Year 6: Manufacturer to cover 35% of replacement cost.
 - 6. Year 7: Manufacturer to cover 20% of replacement cost.
- D. Failure of a module shall be defined as more than 3 fiber breaks per year with a maximum 10 breaks in the 7-year warranty period.
 - 1. A fiber break is defined as a failed LRV score during a membrane integrity test. The failed module(s) is subsequently identified by the individual membrane fiber(s) exhibiting large continuous bubbles during a bubble test where pressurized air introduced into the feed side of the module.
 - 2. During manufacturing and QA testing, the maximum number of pinned/repared fibers before certifying the module for release shall be 20.

PART 2 - PRODUCTS

2.01 ULTRAFILTRATION SYSTEM

- A. Manufacturer
 - 1. The equipment specified herein shall be furnished and commissioned by a single original equipment manufacturer (OEM).

2. The OEM is not responsible for the manufacturing of all components specified herein but must be included with their full UF Equipment Package, unless otherwise coordinated with the Contractor ahead of bidding.
3. The complete system package is specified herein and in noted reference specification sections and includes UF skids, membranes, tanks, heaters, pumps, compressed air systems equipment, instrumentation and analyzers, control panels, pre-assembled skid piping, valves, actuators, and ancillary equipment.
4. Prequalified OEMs for this project, in alphabetical order, are as follows:
 - a. H2O Innovations
 - b. Westech
 - c. Wigen Water Technologies

B. Performance:

1. Filtrate turbidity: shall be less than 0.1 NTU more than 95% of time and shall never exceed 0.3 NTU.
2. Minimum NSF/ANSI Standard 419-2018 LRV_{C-Test} shall be 5 LOG. The minimum regulatory LRV requirements are 3.0 LOG for *Giardia lamblia* and 2.0 LOG for *Cryptosporidium*.
3. Membranes and all materials in contact with water shall be NSF/ANSI 61 certified.

C. The UF system shall be complete and operable designed with the following conditions:

1. Number of UF skids: Thirteen (13).
2. Maximum treatment plant production capacity with one unit out of service: 30 MGD
3. Minimum filtrate capacity at normalized flux per skid: 2.5 MGD.
4. Each UF membrane skid must contain a minimum of 79,000 square feet of effective membrane area, resulting in minimum calculated (non-temperature corrected) flux of 31.6 GFD.
5. The design normalized (temperature corrected) flux at design filtrate flow shall be approximately 60 GFD considering the coldest specified water temperature. The maximum approved piloted temperature-corrected flux rate is 70 GFD.
 - a. Normalized flux shall be calculated as the actual flux rate (flow divided by membrane area) times water viscosity in cP.
6. The minimum UF recovery shall be 95% calculated with backwash waste and daily maintenance cleaning volumes.

D. Raw Water Quality Data:

1. The source of water surface water from the Provo River.
2. Prior to the UF system, the water plant will utilize course screening at the intake and 200-micron fine screening via strainers (strainers by others).
3. The plant can feed an aluminum chlorohydrate coagulant if needed (and to help TOC removal), although the UF pilot study demonstrated the ability to sustainably operate without coagulant.
4. The plant can feed free chlorine to raw water upstream of the UF, although this is not considered to be normal operation.
5. Raw quality data is noted in the table below.

Parameter	Unit	Avg.	Min.	Max.
Aluminum, Total	mg/L	0.11	0.05	0.20
Barium, Total	µg/L	64.8	57.0	82.0
Calcium, Total	mg/L	53.0	44.3	65.3
Iron, Total	mg/L	0.08	0.02	0.32
Magnesium, Total	mg/L	14.6	11.6	17.6
Manganese, Total	µg/L	26.0	5.0	113
Phosphorus, Total as P	µg/L	25.0	10.0	50.0
Silica, (as SiO ₂) Total	mg/L	5.55	1.70	8.00
Sodium, Total	mg/L	13.5	9.10	16.6
Strontium, Total	mg/L	0.33	0.24	0.39
Arsenic, Total	µg/L	1.82	1.50	2.20
Selenium, Total	µg/L	0.73	0.70	0.80
Bromide	µg/L	18.0	10.0	20.0
Chloride	mg/L	21.1	10.9	28.7
Fluoride	mg/L	0.22	0.20	0.30
Sulfate	mg/L	42.0	25.0	47.2
Alkalinity - Bicarbonate (as CaCO ₃)	mg/L	139	122	149
Alkalinity - Carbonate (as CaCO ₃)	mg/L	8.96	2.60	16.7
Alkalinity - Total (as CaCO ₃)	mg/L	143	123	152
Total Dissolved Solids (TDS)	mg/L	254	180	316
Total Suspended Solids (TSS)	mg/L	9.21	4.00	20.0
Total Organic Carbon	mg/L	2.31	1.70	3.50
pH	SU	8.2	7.8	9.0
Temperature	F	Seasonal	36	80

- E. Each UF skid shall include all equipment mounted to a common epoxy-coated steel frame (or multiple frames for field assembly). Skid mounted components including the local

control panel with instruments and control valves pre-wired. All piping on the skid shall have flanged termination points near the edge of the skid for the following services (pipe size per manufacturer):

1. Feed inlet;
2. Filtrate outlet;
3. Air scour inlet;
4. CIP and MC inlet and drain / returns;
5. UF backwash inlet and outlet / drain;
6. Any vent or filtrate exhaust outlet(s);
7. Control air inlet.

F. The UF skid shall be designed to minimize the overall footprint as much as practical. OEM shall note any deviations in excess of the dimensions indicated on the drawings with their bid.

1. Provide the minimum number of membrane elements required to meet the specified flow rate and normalized flux for each skid.
2. Provide space on the UF rack with blind end-caps for future installation of additional membrane elements. A goal of 10% additional installed capacity is desired but must stay within a module rack length and width of 25'-0" and 7'-4", respectively (refers to module rack only and not the front-end pipe/valve assembly). The OEM shall identify the achievable number of spare modules with their bid.

G. General materials of construction include:

1. All materials in contact with water shall be NSF 61 certified. Components not in direct contact with water (such as analyzers fed from a sample port) do not require NSF certification.
2. The skid-mounted water process piping shall be DR 11 HDPE or Schedule 80 PVC. Any piping connections which are pressurized with air during an integrity test shall be DR 11 HDPE or 304 Stainless steel.
 - a. Connections between the UF header and individual membrane elements shall be DR17 HDPE or translucent reinforced PVC tubing having a 125-psi minimum pressure rating.
 - b. For each UF skid, provide one (1) segment of clear PVC piping on the backwash outlet connection to allow visual observation of debris removed during a backwash.

3. The skid-mounted compressed air process piping headers shall be 304 stainless steel or Ashahi AirPro HDPE. Air pipe pressure rating shall be determined by the OEM based on air pressure requirements and an appropriate factor of safety. Individual pneumatic connections to components shall be polyethylene air tubing.
4. The frame shall be epoxy- or powder-coated carbon steel.
5. Valve bodies shall be ductile iron, cast iron, or stainless steel for 4-inches and larger. Valves smaller than 4 inches may be ductile iron, cast iron, stainless steel, or thermoplastic material as determined by the OEM.

H. UF Feed Pumps

1. Each skid will have a dedicated UF feed pump. The feed pumps are not in the OEM scope of supply and each pump and VFD are furnished and installed by others.
 - a. The design point of each UF feed pump is 1800 gpm at 130 feet of head.
 - b. The UF system programming shall control the start, stop, and VFD speed control of each feed pump (one dedicated per skid).

I. UF Strainer

1. Each skid will have a dedicated 200 mesh self-cleaning strainer located between the feed pump and skid. The strainers are not in the OEM scope of supply and each strainers and controls are furnished and installed by others.

J. UF Membranes and Housings

1. Membranes: Basis of design for the membrane elements are HFUG-2020AN as manufactured by Toray.
2. Bid alternate: OEM may provide alternate pricing from at least one of the following equivalent membrane manufactures:
 - a. Hydranautics HYDRAcap MAX 80
3. The membrane skid shall be designed to accommodate the installation of Toray, Hydranautics, and DuPont membranes.
4. Membrane modules basis of design (Toray) shall meet the criteria listed below. Variations for alternate manufacturers must be provided with the bid:
 - a. Flow configuration: Outside-in, hollow fiber.
 - b. Membrane material: PVDF
 - c. Pore size: 0.01 micron, MWCO of 150,000 daltons

- d. Inside Fiber Diameter: 0.7 mm
 - e. Minimum Fiber Wall thickness: 0.2 mm
 - f. Minimum Membrane Area per module: 969 square feet.
 - g. Maximum Transmembrane Pressure as required by manufacturer.
 - h. pH Tolerance (normal operation) 1 – 10 at temperature of 0 to 40 deg C
 - i. pH Tolerance (cleaning) 0-12 at temperature of 0 to 40 deg C
5. Housing:
- a. Body material: PVC.
 - (1) Provide a total of two (2) clear body housings to facilitate visual observation of the membrane fibers. The two locations / skids to receive the clear housings shall be determined by the Owner during the submittal review period.
 - b. Potting Material: Epoxy Resin
 - c. Gaskets: EPDM
 - d. Housing shall feature influent and effluent connections.
6. Quantity:
- a. As required by manufacturer to achieve specified flux and filtrate production.

K. UF Skid Accessories

- 1. Provide a UF filtrate turbidimeter for each UF skid
- 2. Provide one additional filtrate turbidimeter to monitor combined filter effluent turbidity, to be installed in the field by the contractor.
 - a. Turbidimeter: Hach TU5300 low range laser turbidimeter or approved equal
 - b. Controller: Hach SC4500 controller or approved equal
 - c. Skid mounted bubble trap, Hach TU5 SC or approved equal
 - d. Turbidimeter drain will be routed to a floor drain by others
- 3. Provide an influent flow meter for each UF skid
 - a. Type: Magnetic, bi-directional functionality

- b. Manufacturer: Siemens, Endress & Hauser, or approved equal
- 4. Provide an air flow rotameter for visual observation of air flow during air scour operations.
- 5. Provide pressure transmitters in adequate locations for monitoring membrane feed pressure, membrane filtrate pressure (skid control panel to calculate trans-membrane pressure), and air supply pressure.
 - a. Manufacturer: Rosemont (3051), Endress & Hauser, or approved equal
 - b. For each transmitter, provide an analog pressure gauge installed adjacent to the transmitter.
- 6. Provide a local remote I/O panel for each UF skid for communication with the Master UF Control Panel. Refer to “UF System Controls” in this specification for additional detail.

L. UF Skid Valves

- 1. Refer to specification Section 40 23 13.01 for requirements.
- 2. All automatic control valves shall be pneumatically operated (not including solenoid valves).
- 3. Pneumatic control valves shall come fully pre-wired and connected via polyurethane pneumatic tubing to a skid-mounted air supply solenoid panel. The solenoid valves within the solenoid panel shall all be pre-wired.
- 4. Power and signal wiring for the pneumatic valve actuator limit switches shall come pre-wired and landed at the UF skid local control panel for complete valve status monitoring.

M. UF Backwash Pumps

- 1. Backwash water will be supplied by dedicated UF backwash pumps using UF filtrate as the source. The backwash pumps and motors shall be furnished by the UF equipment manufacturer and will be installed by others.
- 2. Number of UF backwash pumps: Three (3) at 100% capacity: two (2) duty + one (1) standby. No more than two UF skids shall be backwashed simultaneously.
- 3. Pump style: Horizontal end suction. Refer to Section 43 21 00.23 for mechanical requirements of the pump.
- 4. The OEM shall determine the flow and head requirements for the backwash pumps such that they are suitable for all compatible UF modules. The water level in the

backwash supply tank is approximately 16 feet below the center elevation of the membrane modules.

5. The UF control system shall be programmed to control all start, stop, and VFD speed control functions of the UF backwash pumps. VFDs provided by others.
6. Maximum horsepower of each backwash pump motor shall be 100 HP.

N. Compressed air system

1. The UF Manufacturer shall provide a complete compressed air system for use as air scour during backwashes and cleaning procedures, membrane integrity testing, and for control of pneumatic valves. The components of the compressed air system shall be one packaged scope of supply furnished by a qualified manufacturer specializing in compressed air systems, including:
 - a. Quincy
 - b. Ingersoll Rand
 - c. Kaeser
 - d. Atlas Copco
2. Compressed air system shall be monitored and controlled by the UF System Master PLC. Refer to Instrumentation Drawings for system control philosophy.
3. Dedicated aeration blowers are not to be provided with the project and the UF system shall have regulators to achieve the desired air pressure for backwash and cleaning processes.
4. Air Compressors
 - a. Quantity: Three (3)
 - b. Type: Rotary Screw
 - c. Minimum Capacity of each compressor shall be sized for all compatible UF modules: Provide no less than 100 ACFM at 100 psi unless otherwise recommended by the OEM.
 - d. Power: 30 HP maximum.
 - e. TEFC NEMA Premium Drive and Fan Motor.
 - f. Microprocessor controls with local LCD display, E-stop, and phase monitor.
 - g. Sound attenuating enclosure.

- h. Five-year warranty.
5. Air Driers
- a. Quantity: Two (2)
 - b. Minimum capacity: 220 CFM at 100 psi unless otherwise recommended by the UF System Manufacturer.
 - c. Non-cycling two-stage heat exchanger configuration.
 - d. Digital dew point display.
 - e. Integrated moisture separator and electronic drain.
6. Compressed Air Filters
- a. Quantity: Four (4) – provide for inlet and outlet of each drier.
 - b. Minimum capacity: 220 CFM at 100 psi unless otherwise recommended by the UF System Manufacturer.
 - c. Coalescing filter with 0.01 micron rating for removal of fine solid particles, water, and oil aerosol.
 - d. Aluminum housing with integral differential pressure gauge.
 - e. Automatic float style drain.
7. Compressed Air Receivers
- a. Quantity: Two (2)
 - b. Minimum capacity: 500 gallons unless otherwise recommended by the UF System Manufacturer.
 - c. Arrangement: Vertical, approximately 36-inch diameter.
 - d. Pressure rating: Not less than 160 psi.
 - e. Provide solenoid valve for user-adjustable timer for automatic tank condensate blow-off.
 - f. Provide safety pressure relief valve.
 - g. For each receiver, provide pressure indicating gauge and high- and low-pressure switches for automated control of the compressors.
8. Compressed Air Accessories

- a. Provide one (1) pressure indicating transmitter to be mounted to the common air header pipe for continuous monitoring of air pressure supplying the UF system.
- b. Provide four (4) spare air filter elements.

O. UF Cleaning System

- 1. Provide two (2) complete cleaning systems each consisting of a tank, heater(s) separate pre-assembled skid with pump, piping, valves, instrumentation, local control panel, and accessories. The system will serve for both the maintenance clean (MC) and CIP functions.
 - a. CIP tank:
 - (1) Number of tanks: one (1) per system, two (2) total
 - (2) Closed top HDPE tank with flat bottom.
 - (3) Provide epoxy- or powder-coated carbon steel tank support stand and all necessary anchor bolts.
 - (4) Each tank volume shall be as required by the OEM to provide the minimum amount of water needed for a single UF skid MC or CIP (greater volume of the two) plus no less than 20% additional capacity.
 - (5) Provide HDPE gusseted flange connections for all required inlet and outlet connections to the tank. Flange sizes shall be determined by the manufacturer to not exceed 10 feet per second at the design flow.
 - (6) Provide a top-flange mounted ultrasonic or radar level sensor with 4-20 mA output for each tank for monitoring of tank level via the UF control system. In lieu of top mounted level sensors, a pressure transducer may be provided. OEM shall coordinate the type of transmitter provided with the Contractor prior to bidding for proper field wiring and installation. Provide any necessary hardware required for installing the equipment.
 - (7) Each tank shall include two (2) flange-mounted immersion water heater.
 - (a) 304 SS flange and Incoloy sheath;
 - (b) 480V, 3 phase, 60 Hz;
 - (c) Include internal thermostat with high temperature cut-off switch;
 - (d) Heaters shall be sized to provide a 50 degree F temperature rise to the full tank volume in no more than two (2) hours, considering both heaters running.

b. CIP pump skid:

- (1) Number of CIP pump skids: Two (2) each with the following:
- (2) Epoxy or powder coated carbon steel frame for mounting the equipment including the pump, strainer, valves, piping, instruments, and electrical equipment.
- (3) Number of pumps per skid: One (1)
- (4) Pumps shall be horizontal end suction style. Refer to Section 43 21 00.23 for mechanical requirements of the pump.
- (5) Pumps shall be sized to accommodate the daily maintenance clean and CIP flow and pressure requirements.
- (6) Pump shall be 480 V, 3 phase, 60 Hz.
- (7) The pump VFD and local disconnect will be furnished and installed by others.
- (8) Provide pump suction and discharge pressure gauges with diaphragm seal.
- (9) Piping shall be Schedule 80 PVC or DR11 HDPE.

c. CIP skid valves

- (1) Refer to specification Section 40 23 13.01 for requirements.
- (2) All automatic control valves shall be pneumatically operated.
- (3) Pneumatic control valves shall come fully pre-wired and connected via polyurethan pneumatic tubing to a skid-mounted air supply solenoid panel.

d. CIP control panel: Provide a local remote I/O control panel for each CIP system (total of two panels) mounted to the CIP pump skid frame for communication with the master UF Control Panel. Each panel shall include the following components.

- (1) Panel shall comply with the mechanical requirements of Division 40 Specifications.
- (2) On/Off/Auto Selector switch for the pump with indicator light.
- (3) On/Off/Auto Selector switch for each heater.
- (4) Tank heater starters.

- (5) Remote I/O accessories for the signal wiring associated with the tank level sensor, free chlorine residual analyzer, pH analyzer, temperature transmitter, limit switches, and feedback signals from the pumps and heaters. Provide suitable ethernet connection shall be communicated with the master UF Control panel via ethernet.
 - (a) Local displays for the analyzers may be wall-mounted and wired by the Contractor if not pre-mounted and wired to the CIP frame. OEM shall coordinate installed location with contractor.
 - (b) Contractor to provide all power cabling from the VFD to the CIP pump.
 - (c) Contractor to provide all field wiring between the tank accessories (heaters, tank level sensor) and local control panel. All other power and signal wiring on the CIP pump frame shall be pre-wired between the equipment and local control panel.
- e. Provide CIP system instrumentation for each tank/pump mounted to the equipment and as follows. Remote displays may be wall mounted
 - (1) Tank water level sensor
 - (2) CIP solution free chlorine residual analyzer
 - (3) CIP solution pH analyzer
 - (4) CIP solution temperature transmitter
 - (5) Pump fault alarms

P. Air Diaphragm Pumps

- 1. Provide two sets of air driven double diaphragm pumps for transfer of liquid sodium hypochlorite and citric acid during cleaning operations.
- 2. Each set of pumps shall be provided on a factory-assembled skid suitable for mounting to the floor as shown on the drawings. Pre-assembled skid shall include all accessories including the metering pumps, suction and discharge piping and valves, discharge pressure gauge, pressure relief valves, adjustable backpressure valve, inlet air connection, and air pressure regulator.
- 3. Citric acid pumps
 - a. Quantity: Two (2)
 - b. Chemical: Citric acid at 50% strength.
 - c. Pump housing material: PVDF

- d. Diaphragm material: PTFE or Santoprene
- e. Delivery rate at 30 psi differential pressure: Approximately 0 to 790 gallons per hour
- 4. Sodium hypochlorite pumps
 - a. Quantity: Two (2)
 - b. Chemical: Sodium hypochlorite at 12.5% strength.
 - c. Pump housing material: PVDF
 - d. Diaphragm material: PTFE or Santoprene as selected by UF System manufacturer for chemical compatibility.
 - e. Delivery rate at 30 psi differential pressure: Not less than 600 gallons per hour
- 5. Accessories
 - a. Provide 20 feet of suitable-sized suction tubing for each metering pump, and 10 feet of suitably-sized discharge tubing for each metering pump.
 - b. Provide a backpressure anti-siphon valve for each chemical metering pump. Materials of valve construction shall be compatible with the chemical being pumped.
 - c. Provide an adjustable pressure relief valve for each chemical metering pump discharge. Contractor shall route the relief tubing to the suction side of the pump.
 - d. Contractor to perform all field installation of pumps, tubing, valves, and pneumatic connections. Include all hose barb fittings and tees, stainless steel hose clamps, and support for piping and tubing.
- 6. Manufacturer:
 - a. Prominent DUODOS Series
 - b. ARO EXP Series
 - c. Wilden AAOD Series

Q. UF Backwash and Cleaning Operations

- 1. Backwash operation: Set-points shall be adjustable and determined by the OEM. Provide the following for initial commissioning unless otherwise specified or required by the membrane manufacturer:

- a. Frequency: once every 30 minutes.
 - b. Backwash (30 seconds).
 - c. Air scour (30 seconds).
 - d. Drain modules (45 seconds).
 - e. Refill modules (45 seconds)
2. Maintenance cleaning: Set-points shall be adjustable. Provide the following for initial commissioning unless otherwise specified or required by the membrane manufacturer.
- a. Start CIP pump with valve positioned to circulate water through the tank while chemical is being added. Once cleaning solution strength setpoints are achieved (free chlorine and/or pH), switch valve positions to send MC solution to UF system.
 - b. Cleaning solution is recirculated through the membrane rack, alternating between the feed side and the filtrate side of the UF modules.
 - c. Frequency: Every other day. One skid at a time.
 - d. Initiated after a normal backwash, fully automated.
 - e. Soak for 20 minutes in 300 mg/L chlorine solution. The UF PLC shall call for chlorine until the concentration setpoint is reached. Feed of chlorine solution to the CIP tank will be performed and controlled by others (supplied from the main plant chlorine gas facility). However, the UF control system shall call for chlorine using discrete output(s) to the plant SCADA system.
 - f. Optional addition of citric acid for the soak period. The UF PLC shall call for citric acid until the pH setpoint is reached. Feed of citric acid solution via the air diaphragm pumps to the CIP tank shall be controlled by the master UF Control panel.
 - g. Air scour every 5 minutes for 30 seconds.
 - h. Total time required is 23 minutes.
3. CIP operation: Set-points shall be adjustable. Provide the following for initial commissioning unless otherwise specified or required by the membrane manufacturer.
- a. Frequency: Initiated by an operator.

- b. Valves and circulation pump shall be a completely automated operation when initiated by the operator. Chemicals will be added to the tank with manual control of the chemical pumps by operators prior to initiating a clean.
- c. The HMI shall notify the operator when the Transmembrane Pressure (TMP) reaches the maximum setpoint. Perform CIP after a normal backwash.
- d. Procedure: Soak membranes for up to 6 hours with any of the following or as recommended by the membrane manufacturer:
 - (1) 1,000 to 3,000 mg/L chlorine. Feed of sodium hypochlorite solution via the air diaphragm pumps to the CIP tank shall be controlled by the master UF Control panel.
 - (2) Citric acid solution at a pH as recommended by the OEM. Feed of citric acid solution via the air diaphragm pumps to the CIP tank shall be controlled by the master UF Control panel.
 - (a) Chemical is fed from a removable tote and other acids, or caustics, may be substituted for pH adjustment as needed.
- e. Air scour every 5 minutes for 30 seconds during soak.

R. UF System Controls

- 1. Provide instrumentation and PLC/OIT-based control system to control the UF and CIP systems. All instrumentation required to control and monitor the operation of the system shall be provided including all PLC and OIT programming for all supplied equipment.
- 2. The UF system will be integrated with the balance of the water plant SCADA system provided by others.
- 3. General functionality:
 - a. The number of UF skids will running and instantaneous flow rate will be determined based on the following criteria:
 - (1) Operator selection of dedicated online and offline skids, and maximum number of skids to run.
 - (2) Call for water production based on the operating levels in the water plant clearwell.
 - (3) The UF system will control the VFD speed of the UF feed pumps. One pump is dedicated for each UF skid and the pumps and VFDs are provided by others.

- b. If the feed pressure exceeds the maximum feed pressure or the transmembrane pressure specified by the manufacturer, the skid shall shutdown and send an alarm.
- c. If filtrate turbidity exceeds 0.15 for two consecutive 15 minute periods, the skid shall shutdown and perform an Integrity Test. It cannot be placed back in service until it passes. Each turbidity meter shall have an air trap and solenoid valves to automatically isolate the meter during backwash.
- d. An air integrity / pressure decay test shall be performed for each skid for any of the following conditions:
 - (1) No less than once per day
 - (2) After every maintenance clean
 - (3) After every CIP
- e. Setpoint for integrity testing procedures and setpoints shall be pre-programmed by the OEM and include the following:
 - (1) Start pressure: 15 psi
 - (2) Pressure decay shall be measured during the integrity testing sequence and used to determine the LOG Reduction Values (LRV) of the system using the following equation:

$$LRV = \log \left(\frac{Q_p * ALCR * P_{atm}}{\Delta P_{Test} * V_{sys} * VCF} \right)$$

Where Q_p = Design capacity of filtrate flow (gpm)
 $ALCR$ = Air-to-liquid Conversion Ratio (by OEM)
 P_{atm} = Atmospheric Pressure (psi)
 ΔP_{test} = Pressure decay during test (psi/min)
 V_{sys} = Volume of the UF system (gal)
 VCF = Volumetric concentration factor (1, unitless)

- (3) Test time for sequences shall be as follows:
 - (a) Pressurization and water purging: 5 minutes maximum
 - (b) Pressure decay monitoring: 5 minutes minimum
 - (c) Air purge and water refill: 5 minutes maximum
- (4) Alarm setpoints shall be as follows:

- (a) The UF system must achieve 3 LRV for giardia and 2 LRV for cryptosporidium.
 - (b) An general alarm shall notify operators when the LRV falls below a value of 4.0.
 - (c) An LRV result of 3.5 or less shall prohibit the UF skid from returning to service until repairs can be made and an integrity test meets the requirements.
- f. Provide one remote I/O panel for each UF skid, one remote I/O panel for each CIP skid, and one master UF system control panel with user interface touchscreen.
- g. At a minimum, display the following information / on the Master Control Panel HMI. Graphic screens shall be the standard offering of the manufacturer given that they meet the minimum following requirements.
 - (1) Use the following color coding for motorized equipment:
 - (a) Flashing Red: Alarm / fault status
 - (b) Green: Running
 - (c) Yellow: Standby or offline
 - (2) For each UF skid:
 - (a) Overview of all skids
 - (b) Status of UF (normal operation, standby, backwash, maintenance clean, CIP, or fault condition).
 - (c) Water quality and other analyzers outputs including influent and effluent turbidity, temperature, flow, and pressure. Raw water temperature will be measured using instrumentation by others and through the balance of plant SCADA system and communicated with the UF control system.
 - (d) Calculated membrane operational parameters including flux, permeability, transmembrane pressure.
 - (e) Speed command output for VFD speed of the feed pump;
 - (f) Position of all actuated valves;
- h. At a minimum, display the following information on the HMI for each CIP panel

- (1) Status and VFD speed of the CIP pump;
 - (2) Water level in the CIP tank
 - (3) Water temperature
 - (4) Status of the CIP tank heater.
 - (5) pH of water in the CIP tank
 - (6) Free chlorine residual in the CIP tank
- i. Include a performance monitoring software system for purposes of:
- (1) Automatic data acquisition
 - (2) Data trending
 - (3) Report generation
 - (4) Alarm management including notification and alarm archiving
 - (5) Facilitating system performance analysis
 - (6) Facilitating performance optimization

PART 3 - EXECUTION

3.01 STARTUP AND COMMISSIONING ACTIVITIES

- A. I/O checkouts and testing of the UF and CIP systems shall be accomplished prior plant startup.
- B. Installation of membranes
 1. If the skid is not shipped with membrane modules installed, field installation work shall conform to the Membrane Manufacturer's recommended procedures and instructions.
 2. Provide for the services of a factory trained service technician to be present to supervise the installation of the membranes.
- C. Functional Testing
 1. Each skid is to be operated at representative flows with automatic instrument control as required to confirm responsiveness over the design operating range. Testing shall continue until the system is run for two consecutive days without abnormal

interruption and shall include normal backwashing and MC cycles of the UF skid and CIP system.

2. No less than two successful start-up and shutdown sequences shall be demonstrated prior to the start of the functional run test.
3. The OEM shall return to the project site when the first CIP is scheduled to occur and perform functional testing. Successful functional testing must be demonstrated for each skid (one CIP per skid).

D. Performance Testing and Training

1. Time of Performance Testing: The performance testing for the UF and CIP systems shall occur following completion of functional testing and completion of all facilities and equipment required for the testing. Final acceptance of the systems will be contingent upon successful performance testing. See "SYSTEM TRAINING" section for further requirements.
2. Duration of Performance Test: The system shall be tested for five consecutive days during normal plant operation shifts. The manufacturer shall be fully responsible for every aspect of the performance test. Representatives of the manufacturer and shall be on site during the entire performance test. Representatives of the Engineer and Owner may also be present during the performance test.
3. The UF OEM shall conduct formal training with the Owner during the performance testing period, and may extend beyond the performance period as needed for the extent of training.
4. Performance Test Conditions: All systems shall be tested under design operating conditions.
5. Data Collection During Performance Test: The following continuous data shall be collected hourly unless otherwise specified during the performance testing:
 - a. Water Quality: water temperature, feed water pH, feed water turbidity, and UF filtrate turbidity. Readings may be taken from the plant instrumentation provided the instrumentation is operable and calibrated at the time of the test.
 - b. Mechanical Data: Process stream pressures, UF transmembrane pressure, process flow, membrane flux, chemical dosages, and duration of operating, startup and shutdown times.
6. Test Report: A formal startup and testing report shall be produced and submitted to the Engineer for all testing activities. Report shall contain results for all activities performed during testing. Results from all testing shall be tabulated, trended, and graphed as appropriate. Discussion of testing, along with conclusions and recommendations, shall be presented in the test report.

- E. Field Representative: The equipment shall provide the services of a qualified field representative for all startup and commissioning procedures. The representative shall perform all testing, operation, and debugging of the systems. A minimum of thirty (30) business days in a total of four trips shall be included in the base bid for onsite representation to perform system checkouts, startup and commissioning, testing, and Owner Training. The OEM proposal shall include the additional cost per day information.

3.02 SYSTEM TRAINING

- A. The manufacturer shall provide the services of a qualified representative(s) to provide training during the startup and commissioning period to instruct the Owner's personnel on proper operation, installation, sampling, cleaning, and maintenance for the systems provided in this specification. Topics of discussion shall include, at a minimum:

1. UF System

- a. General UF concepts and definitions such as in-side out versus outside-in feed arrangements, flux, transmembrane pressure, permeability, air scour, etc.
- b. The process of how UF works including backwashing and cleaning functions.
- c. Problems caused by particulates, foreign materials, and dissolved foulants.
- d. Membrane chemical compatibilities with oxidants, acids, and bases.
- e. Monitoring techniques of how to detect problems.
- f. Maintenance: Issues involving the maintenance of the UF units and CIP systems.
- g. Cleaning procedures including desired pH, chlorine dosages, temperatures, flow rates, cycle times, etc.
- h. Controls/operation of this specific installation, including touch screens, logic, instrumentation calibration, and other operations.

3.03 REMOTE MONITORING

- A. The OEM shall provide one year of remote monitoring the system operating parameters using a VPN connection in their base cost. At the completion of the one-year period. The Owner may select to renew the OEM monitoring program.
- B. UF performance data collected and monitored by the OEM during this period shall be used to compile a monthly status report with a complete analysis of all normalized data with recommendations for any adjustments to operation and maintenance. OEM shall deliver the monthly report to the Owner in PDF format once per month.

- C. Manufacturer shall recommend when the first CIP is required and be present onsite to oversee the CIP procedures and perform general acceptance testing of those systems. The OEM shall assume being onsite for a total of two (2) days to oversee a CIP of all 13 UF skids.

3.04 CONTRACT CLOSEOUT:

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

Attachment A

Geotechnical Report

Geotechnical Design Report

Provo River Water Treatment Plant
Provo, Utah

Provo City | Hansen, Allen & Luce, Inc.

Project reference: Provo Water Treatment Plant
AECOM Project number: 60670884
HAL Project number: 035.15.420

September 23, 2022

Quality information

Prepared by

Bryan W. Franke, P.E.
Senior Project
Geotechnical Engineer

Checked by

Stoney Mather, P.E.
Senior Geotechnical
Engineer

Verified by

Mathew Francis, P.E.
Senior Principal

Approved by

Brock Hodgson, P.E.,
Project Manager

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--	X	Mike Chambers / Hansen, Allen & Luce, Inc.
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Prepared for:

Provo City | Hansen, Allen & Luce, Inc.
Mike Chambers, PM
Hansen, Allen & Luce, Inc.
859 W. South Jordan Pkwy. Ste. 200
South Jordan, UT 84095

Prepared by:

Bryan W. Franke, P.E.
Senior Project Geotechnical Engineer
T: 801.904.4047
M: 801.696.4964
E: bryan.franke@aecom.com

AECOM
756 East Winchester Street
Suite 400
Salt Lake City, UT 84107
aecom.com

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1. Introduction

AECOM Technical Services, Inc. (AECOM) is pleased to provide this geotechnical report for the new water treatment plant (WTP) and finished water transmission pipeline in Provo City (City). The purpose of this report is to present the findings of our geotechnical field exploration and laboratory testing as well as provide geotechnical recommendations for the design and construction of project improvements.

1.1 Scope of Services

Our scope of services for this geotechnical study includes the following:

- Review of pertinent in-house geotechnical data, aerial photographs, and published geologic maps, soils data, and literature.
- Coordination and mobilization for subsurface exploration, including marking of existing utilities through Blue Stakes of Utah.
- Drilling, logging, and sampling of 7 exploratory borings and performance of 6 cone penetration tests (CPTs) at the project site and along the transmission pipeline alignment to depths ranging from 16 to 121 feet (ft) to assess subsurface conditions and to obtain soil samples for laboratory testing.
- Assignment and performance of laboratory tests to assess physical and engineering properties of subsurface soils, including water content, Atterberg limits, particle size distribution, organic content, consolidation, and corrosion suite testing (Chlorides, pH, Resistivity, Sulfates, Chlorides, Sulfides, and Soluble Salts) on selected soil samples.
- Compilation and engineering analysis of collected data to develop design recommendations.
- Preparation of this report presenting data, findings, and geotechnical design recommendations regarding the subject project.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing.

1.2 Project Description

Our understanding of the project is based on our discussions with the design team and City Public Works personnel. Our understanding is that the new WTP will be constructed south of 2230 North Street, and just west of Freedom Boulevard in Provo, Utah. A finished water transmission pipeline approximately ½-mile in length will extend southward from the planned WTP and then eastward along Stadium Avenue, crossing University Avenue and Canyon Road (150 East Street) to connect with existing ductile iron pipelines. The new 36-inch diameter ductile iron transmission pipeline is anticipated to be constructed primarily using cut and cover methods, with depth of cover ranging from approximately 4 to 15 ft. Cut and cover methods are also anticipated for the University Avenue crossing rather than a trenchless excavation, which had been under consideration. The project will include demolition of the existing parking area at the new WTP site.

The new WTP and associated structures are assumed to be supported on mat foundations or shallow spread and strip footings based upon discussions with the structural engineer. From the preliminary plan sheet, the WTP will treat up to 30 million gallons per day (MGD) and will include two 1-million-gallon (MG) clearwell tanks and a pump station. The treatment plant will have a finished floor near final grade with elevation (El.) 4,632.75 ft above mean sea level (msl) and the top of the tanks will be slightly above final grade, near El. 4,635.7 ft msl. The pump station is planned to have a bearing elevation below grade, near El. 4,616.3 ft msl.

1.3 Site Description

The new WTP project area is less than two miles west of the foot of the Wasatch Mountain Range in Utah County, Utah. The area is less than 5 miles from the eastern shoreline of Utah Lake and about 50 miles from the Great Salt Lake, which is northwest of the project site. The project site is located along the west side of Freedom Boulevard approximately 500 ft south of 2230 North Street in an existing asphalt-paved parking area. Residential parking areas border the project site to the west, south and north extending to multifamily residences, most notably Raintree Apartments. A project vicinity map is provided in **Appendix A**. At the time of performance of the site investigation and preparation of this report, the project site was relatively flat, with most of the ground surface area covered with asphalt paving, sloping slightly downward to the west. Some mature trees were situated near the western edge of the site, and an overhead power transmission line extended roughly north to south near the eastern edge of the site; some grasses and other small vegetation were present in the unpaved powerline easement. The northwest region of the parking area at the project site was being used as a temporary staging area to support construction occurring offsite. Some debris and garbage was observed along the western side of the site.

1.4 Alignment Description

The transmission pipeline conveying treated water is planned to extend southward along Freedom Boulevard from the new WTP, then eastward to connect with an existing pipeline near the Lavell Edwards Football Stadium. The alignment lies within asphalt paved roads and parking areas. Along the alignment Freedom Boulevard is a four-lane asphalt-paved roadway and includes a center median lane. Concrete curb and gutter extend along both sides of the roadway, overhead power transmission extends along the west side of the roadway right-of-way, and indications of buried utilities are also present.

The project alignment extends eastward from Freedom Boulevard through paved parking areas; the alignment is at similar latitude as Stadium Avenue, located east of 150 East Street and just North of the Lavell Edwards Football Stadium. Between Freedom Boulevard and University Avenue, the alignment extends through a paved parking area. The area includes an overhead electrical power transmission line, associated utility easement, and chain link gated accessways to/from the parking area. Several grass sport fields are located to the south and to the north of the parking area, and a residential development borders the area on the north, from west of University Avenue to one of the grass fields (to approximately halfway between University Avenue and Freedom Boulevard).

East of University Avenue, the alignment extends through another paved parking area with the same power transmission line extending eastward toward 150 East Street. The alignment is near the north end of the parking area; residential developments and religious structures are located just north of the alignment. The ground surface elevation along the pipeline alignment is relatively level along Freedom Boulevard, but generally rises between Freedom Boulevard and 150 East Street.

2. Site Characterization

2.1 Regional Geology

The site setting between Utah Lake and the Wasatch mountains is within the eastern margin of the Basin and Range physiographic province. The Basin and Range consists of an alternating series of generally north-south trending narrow mountain ranges and valleys (basins) extending from approximately Reno, Nevada, in the west to Salt Lake City, Utah, in the east. The basins and ranges that are part of the Great Basin were created largely by normal faulting during a period of extensional tectonic activity that continues to be active in the present time.

The geology of the areas surrounding the Great Salt Lake, including the project site, is dominated by the former Lake Bonneville, a freshwater lake that covered much of northern Utah and extended into Idaho and Nevada as recently as 12,000 years ago during the Pleistocene Epoch. During this time, lacustrine

sediments including fine-grained deep-water deposits, as well as coarse-grained beach, turbidite (subaqueous landslide), and alluvial deposits were deposited in areas surrounding the Great Salt Lake. As Lake Bonneville receded, lacustrine soils were overlain by alluvial fan deposits placed along major drainages emanating from the mountains as well as some aeolian (wind-derived) deposits in certain locations. The Great Salt Lake and Utah Lake are the modern remnants of Lake Bonneville.

2.2 Mapped Soil Conditions

Geologic maps that include the project site indicate surficial deposits to be primarily composed of young alluvial fan deposits with a matrix of sand silt and clay deposited by debris flows, debris floods, or streams (Qafy); some stream-terrace deposits with only minor amounts of clay (Qat1); and deltaic deposits of the regressive (Provo) phase of the Bonneville Lake cycle (Qldp) consisting of well-sorted pebble and cobble gravel with a matrix of sand and silt interbedded with thin pebbly sand beds (Solomon et al. 2010).

2.3 Geologic Hazards

2.3.1 Seismicity

The project site is located within the Intermountain Seismic Belt, one of the most seismically active areas in the interior western United States. Earthquakes of moment magnitude of 7.0 or more have occurred repeatedly in relatively recent geologic history along the nearby Wasatch fault zone, which generally runs along the foot of the Wasatch Mountains. The main surface expression of the Wasatch fault zone is located approximately 1-1/2 miles east of the project site. The Wasatch fault zone is one of the longest and most tectonically active normal faults in North America and half of the estimated 50 to 120 post-Bonneville surface-faulting earthquakes in the Wasatch Front region have been on the Wasatch fault with an estimated slip rate of between 1 and 5 millimeters per year (Black et al. 2004). Additional quaternary or younger faults in the nearby vicinity of the project site with seismic potential include the Utah Lake faults about 5 miles west of the project site, the Round Valley faults about 13 miles northeast of the project site, and the Little Diamond Creek fault about 14 miles southeast of the project site. The Utah Lake, Round Valley, and Little Diamond Creek faults are normal faults with slip rates less than 0.2 millimeters per year.

2.3.2 Liquefaction

Seismically induced liquefaction occurs from the development of excess pore pressures in soil during earthquake loading. This most typically occurs in loose, saturated, cohesionless soils. The generation of excess pore pressure decreases effective stresses within the liquefied soil layer, weakening the soil. Liquefaction effects can include sand boils, settlement, lateral spread, loss of bearing capacity, and increased drag force on deep foundations associated with post-liquefaction settlement.

The Utah Geological Survey (UGS) provides geologic hazard maps that include portions of Utah County, one of which qualitatively shows liquefaction potential in the project area (Christenson and Shaw 2008). Liquefaction potential was assigned on the basis of regional soil and groundwater conditions in conjunction with earthquake ground-shaking probabilities. Based on the liquefaction potential map, the project area is shown as having moderate liquefaction potential. This assessment is consistent with subsurface conditions encountered on our explorations (encountered subsurface conditions are summarized in **Section 3.4** of this report). Based on mapped conditions and our subsurface explorations completed to date at the project site, there could be a risk of liquefaction in some soil layers at the site.

2.3.3 Surface Fault Rupture

The UGS geologic map for the area qualitatively shows potential for surface fault rupture in the project area (Christenson and Shaw 2008). Surface fault rupture is defined as fault-related offset or displacement of the ground surface that may occur due to an earthquake. Relative displacements may be anywhere from a few inches to several feet and can occur horizontally or vertically. The relative displacement commonly recurs along existing fault traces and can result in significant damage if the displacement occurs beneath a building. The surface-fault-rupture potential map shows that the project is not in a surface-fault-rupture special study area (Christensen and Shaw 2008).

The Utah Quaternary Fault and Fold database contains faults that are considered “active” or have an activity class of Quaternary (1.6 million years) or younger. Considering that mapped quaternary faults are more than a mile east of the project site and the transmission pipeline alignment, our opinion is that the risk of surface fault rupture in the project area is low.

3. Subsurface Investigation

A subsurface investigation was performed at the project site and along the transmission pipeline alignment in support of the project's design and construction. Seven (7) soil borings, advanced to depths ranging from approximately 16 to 118 ft, were completed on March 21-23, 2022, and July 28-August 2, 2022. As part of the subsurface investigation plan, six (6) cone penetration tests (CPTs), advanced to depths ranging from 71 to 121 ft, were completed on June 27-28 and July 29, 2022, at the project site. Prior to drilling and CPT soundings, identification and marking of existing utilities was coordinated through Blue Stakes of Utah in the vicinity of each exploration. Drilling and CPT services were provided by our subcontractor, ConeTec, Inc. of Salt Lake City, Utah. The purpose of the subsurface exploration was to gather information regarding subsurface materials and to collect soil samples for further engineering characterization and testing. A description of the site conditions at the time the explorations were performed is provided in **Section 1.3**.

The as-drilled location of each exploration was surveyed by Hansen, Allen & Luce, Inc. Aerial maps showing exploration locations at the new WTP site and along the transmission pipeline are provided in **Appendix A**.

3.1 Borehole Drilling and Sampling Methods

Exploratory borings performed in March of 2022 were advanced using high-frequency resonant energy vibration methods (sonic drilling) to depths ranging from approximately 16 to 118 ft below ground surface (bgs), using a Boart Longyear LS 600 track-mounted drill rig, equipped with 6-inch diameter casing and 4.75-inch diameter core barrel button bit. Exploratory borings performed in July and August 2022 were advanced using overburden drilling eccentric (ODEX) to depths ranging from approximately 20 to 24 ft bgs, with a 4.5-inch diameter ODEX bit, and using mud rotary drilling to depths ranging from approximately 20 to 81 ft bgs, with a 3.875-inch diameter tricone bit. The explorations in July and August 2022 were performed using a FRASTE MD-XL track-mounted drilling rig. Logs documenting subsurface conditions that were encountered in the exploratory borings and a Key to Boring Logs are provided in **Appendix B**.

Soil samples were obtained by driving a 2.0-inch outside-diameter (OD) split barrel, standard penetration test (SPT) sampler and 3.0-inch OD split barrel, modified split-spoon sampler (modified California style sampler) in general accordance with ASTM International (ASTM) Standard D1586 (2018), pushing a 3.0-inch OD thin-walled tube sample (Shelby tube) in general accordance with ASTM Standard D1587 (2015), or collecting, in bags, disturbed samples of the sonic core material at depth. Penetration resistance (blowcount) was recorded for each 6-inch interval while driving the split-barrel sampler with an automatic trip 140-pound hammer, dropped from a height of 30 inches. The blowcount recorded over the driven sample interval was used along with pocket penetrometer and torvane devices for an indication of relative density and consistency of in-place soil materials. The blowcount or N-value is recorded on the boring logs (included in **Appendix B**), denoted by “N.” Additionally, the blowcount at each sample depth was corrected for drilling conditions, adjusted for estimated hammer energy to obtain the N_{60} value, and adjusted for overburden stress at the depth of each sample to obtain the $(N_1)_{60}$ value. The N_{60} and $(N_1)_{60}$ values are also shown on the boring logs included in **Appendix B**.

AECOM geotechnical personnel observed subsurface explorations, maintained detailed logs of subsurface conditions encountered in each boring, classified encountered soils, and collected soil samples for laboratory testing. Encountered soils were classified at the time of drilling using the Unified Soil Classification System (USCS) in general accordance with ASTM Standard D2488 (2017). Soil samples were placed into re-sealable plastic bags, or 5-gallon buckets, depending on the type of

sampling performed, labeled with sample location and depth information, and transported to the laboratory testing facility. A summary of geotechnical explorations performed for the project is presented in **Table 3.1**.

In the first phase of drilling (Initial), exploratory borings were performed by sonic drilling methods. Sonic drilling uses vibration to advance the casing behind the core barrel. While this drilling method provides a continuous soil core for classification and sampling, in-situ measures of soil density and geotechnical laboratory testing may be adversely impacted by vibration. Consequently, blowcounts recorded and reported on the boring logs in **Appendix B**, may be lower than those from SPTs using traditional rotary drilling and may not reflect the typical correlation to actual *in situ* condition of the soil. The vibration may also cause some disturbance to tube soil samples.

Exploratory borings completed during the second phase of drilling (Follow Up) were advanced using ODEX and mud rotary drilling methods to gain additional perspective. ODEX drilling was used to advance borings through the upper soil deposits with dense gravel and cobbles, but ODEX drilling also causes vibration that can lead to sample disturbance and can influence blowcounts. Below 20-24 ft, mud rotary drilling was performed to improve reliability of field blowcounts and reduce sample disturbance.

3.2 Borehole Abandonment

After each exploratory boring was completed, the borehole was backfilled. For borings completed along the transmission pipeline alignment and above the observed groundwater, boreholes were backfilled with bentonite chips to within approximately 1 foot of the ground surface and finished near the ground surface with sand/gravel aggregate and then a cold patch asphalt. For borings completed in the vicinity of the new WTP site, boreholes were backfilled using portland cement-bentonite grout to within 0-10 ft of the ground surface via tremie pipe and with bentonite chips within 0-10 ft of the ground surface. Borings performed within paved areas at the project site were finished near the ground surface with sand/gravel aggregate and cold patch asphalt.

3.3 Cone Penetration Tests

The CPT soundings were completed using a 25-ton, truck-mounted CPT rig, equipped with a 60-degree-apex-angle piezocone with a 15-square-centimeter tip and net area ratio of 0.8. The CPT soundings were performed by pushing an approximately 1.7-inch-diameter instrumented cone into the ground with a set of hydraulic rams to collect relatively continuous tip, sleeve, and pore pressure measurements of subsurface soil conditions. The sleeve area was approximately 225 square centimeters, with an offset between measured tip and sleeve resistance of 0.1 meter. This offset is accounted in the reported data. The CPT soundings were performed in accordance with ConeTec's CPT operating procedures, which are reported to be in general accordance with the current ASTM Standard D5778 (ASTM 2012b). Measured cone tip resistance was corrected for pore pressure effects (corrected tip resistance denoted as "q_t") for reporting. The results of the CPT soundings are included in **Appendix C**.

Table 3.1 Summary of Geotechnical Explorations

Exploration ID	Investigation Phase	Depth (ft)	Groundwater Depth (ft)
DH22-HDD-01	Initial	43.0	Not Encountered
DH22-P-01	Initial	18.0	Not Encountered
DH22-P-02	Initial	18.0	Not Encountered
DH22-P-03	Initial	16.1	Not Encountered
DH22-WTP-01	Initial	118.0	13.8
DH22-WTP-02	Follow Up	80.0	15.2
DH22-WTP-03	Follow Up	81.0	15.0
CP22-WTP-01	Follow Up	120.1	(16.1 ²)

Exploration ID	Investigation Phase	Depth (ft)	Groundwater Depth (ft)
CP22-WTP-02	Follow Up	74.8	18 ¹ (18.5 ²)
CP22-WTP-03	Follow Up	121.3	15.8 ¹ (25.8 ²)
CP22-WTP-04	Follow Up	71.2	13 ¹ (13.6 ²)
CP22-WTP-05	Follow Up	81.0	15 ¹ (20.1 ²)
CP22-WTP-06	Follow Up	74.2	(23.9 ²)

Notes:

1. Groundwater depth observed during pre-drilling activities.
2. Groundwater depth estimated based on shallowest pore pressure dissipation (PPD) performed during CPT sounding.

3.4 Encountered Subsurface Conditions

General descriptions of encountered subsurface conditions, including fill materials and native soil encountered in the exploratory borings at the project site are presented in subsequent sections.

3.4.1 Fill Materials

Subsurface explorations at the project site encountered fill materials from the ground surface to depths of approximately 0.5 to 2.5 ft bgs. Fill materials, including disturbed native materials and imported materials placed without documentation or by uncontrolled means, generally are not suitable to support structures. The sampled fill materials primarily were composed of silty sand, silty sand with gravel, poorly graded sand with silt and gravel, and sandy silt with gravel. The fill material was encountered directly below the existing 2 to 5 inches of asphalt concrete pavements. No documentation of fill placement has been provided to us for consideration. In addition to the fill materials encountered in the exploratory borings, fill is anticipated to be encountered at locations beyond and between the boring locations, extending to varying elevations that may be associated with existing roadway right-of-way, previous site grading, or buried utility improvements.

3.4.2 Native Soils

Native soils encountered immediately beneath the fill materials include gravel, sand, silt, and clay. Primarily coarse-grained soils, including silty/clayey sands and gravels, were encountered at shallow depths on the logs; however, several clay and silt strata were also encountered. Below the coarse-grained soils, thicker deposits of fine-grained sediments, including clays and silts with much less sand and gravel, were encountered. A couple of relatively dense layers of sand were also encountered in the deeper sediments. Consistent with the proximity to the Provo River and the alluvial deposition of some of the native soils, variation in layer depth and thickness was observed in the explorations performed.

3.4.3 Groundwater

Groundwater was not encountered to the depth explored in the four soil borings along the project pipeline alignment. At the WTP site, groundwater was initially observed during drilling of soil borings or pre-drilling for CPTs at depths ranging from 13 to 18 ft bgs (El. 4,608 to 4,613 ft msl). Groundwater depth estimations in CPT soundings is based on shallowest pore pressure dissipation (PPD) test performed during the CPT sounding, and are somewhat deeper than the depths encountered during drilling and pre-drilling, approximately 13.6 to 25.8 ft bgs. The estimated equilibrium pore pressure reached in some of the deeper PPD tests showed little to no head, suggesting that full hydrostatic pore pressure conditions may not exist in some materials and that a perched or falling head groundwater condition could exist at the site. However, for the geotechnical analyses performed and reported herein, hydrostatic, saturated conditions were assumed.

Considering that groundwater was observed in the explorations and considering the depth of our explorations along the project pipeline alignment, groundwater should be anticipated in localized regions

and should be considered for design and construction of project improvements. In general, groundwater levels fluctuate seasonally because of possible variations in ground surface topography, subsurface geologic conditions, rainfall, irrigation, and other factors. A detailed groundwater analysis was beyond the scope of this geotechnical study; however, groundwater typically is higher in the late spring months and lower in late fall to early winter. Groundwater level also may be influenced locally by nearby construction activities, or by dewatering efforts for excavations during construction.

4. Laboratory Testing

Laboratory testing was performed by Ninyo & Moore in North Salt Lake, Utah, on selected soil samples, which were collected from exploratory borings completed for this study. The following subsections describe the laboratory testing performed on collected soil specimens.

4.1 Index Properties

Index property testing was conducted to measure physical properties of the materials and to confirm field soil classifications. Index tests included the following:

- Natural moisture content (ASTM Standard D2216 2019)
- Atterberg limits (ASTM Standard D4318 2017)
- Sieve analysis (ASTM Standard D6913 2017)
- Hydrometer analysis (ASTM Standard D7928 2017)

The results of laboratory testing are presented in **Appendix D**, and select results are summarized in **Table 4.1**. The original field classifications, as well as the revised classifications based on laboratory data, are noted in the table. Note that the final borings logs were updated to include index laboratory test results at the tested depths on the logs, and laboratory Unified Soil Classification System (USCS) classifications are reported on the logs.

4.2 Corrosion Properties

Analytical testing was performed to provide information on corrosion potential of onsite soils to buried metal and/or concrete for use in corrosion design of project improvements. Specifically, corrosion tests were focused on bulk soil samples that could come into contact with pipelines, hydraulic structures, or other subsurface facilities. The tests performed included pH (EPA 9045D, USEPA 2015), Soluble Chloride (EPA 300.0, USEPA 2015), Soluble Sulfate (EPA 300.0, USEPA 2015), and Electrical Resistivity (SSSA 10-3.3, USEPA 1991). The results of corrosion testing are presented **Appendix D** and summarized in **Table 4.1**.

The results of six electrical resistivity tests were between 610 and 1930 ohm-cm (average 1425 ohm-cm) and indicate that soils at the site may exhibit severe corrosion potential to buried metal. Chloride content results (10 to 431 ppm) are less than an approximate threshold of 450-500 ppm, above which soils should be considered corrosive to metal. The pH results (8.1 to 9.5) indicate some alkalinity but do not indicate significant influence on corrosion potential. Sulfate content results (12 to 379 ppm) indicate a negligible to moderate potential for deleterious amounts of water-soluble sulfate ions that can react unfavorably with concrete (American Concrete Institute [ACI] 2019).

Table 4.1 Laboratory Test Results Summary

Laboratory Test	Test Results	Notes
Atterberg Limits		
Liquid Limit	NP to 48	Fines classify as non-plastic silt to medium plasticity clay
Plastic Limit	NP to 25	

Laboratory Test	Test Results	Notes
Plasticity Index	NP to 24	
Moisture Content	2 to 37 percent	Slightly moist to wet
Material passing #200 sieve	5 to 97 percent	--
Dry Density	94 to 98 pounds per cubic foot	--
Organic Content	29 percent	DH22-P-03, sampled from 4 to 6 ft
Sulfate Content	12 to 379 ppm	Negligible to moderate sulfate exposure
pH	8.1 to 9.5	--
Chloride Content	10 to 431 ppm	Less than 500 ppm; negligible corrosivity
Resistivity	610 to 1930 ohm-cm	Severe corrosion potential to buried metal

Notes:

"--" denotes a blank entry; cm = centimeter; kg = kilogram; mg = milligram; ppm = parts per million

4.3 One Dimensional Consolidation

One-dimensional consolidation tests (ASTM Standard D2435 2020) were performed on Shelby tube samples to assess settlement properties of site soils. Reported traditional consolidation parameters are summarized in **Table 4.2**. The consolidation parameters (CR, RR, and OCR) reported herein for the current study were developed from the consolidation plots using the Casagrande graphical method and were used in foundation settlement analysis. Additional consolidation test data are provided in **Appendix D**.

Table 4.2 Summary of Consolidation Test Results

Boring	Sample Depth (ft)		USCS	CR	RR	P' _c (ksf)	OCR
	Top	Bottom					
DH22-WTP-01	36.5	38.5	CL	0.106	0.016	3.6	1.2
DH22-WTP-01	56.5	58.5	CL	0.163	0.010	6.9	1.7
DH22-WTP-01	66.5	68.5	CL	0.289	0.035	7.9	1.7
DH22-WTP-01	96.5	98.5	CL	0.149	0.017	6.5	1.0
DH22-WTP-02	35.0	37.0	CL	0.115	0.010	5.7	2.0
DH22-WTP-02	37.0	39.0	CL	0.071	0.008	5.8	1.9
DH22-WTP-02	58.0	60.0	CL	0.113	0.007	7.7	1.8
DH22-WTP-02	71.0	73.0	CL	0.080	0.011	6.1	1.2
DH22-WTP-03	32.0	34.0	CL	0.126	0.011	4.8	1.8
DH22-WTP-03	54.0	56.0	CL	0.125	0.014	9.3	2.3
DH22-WTP-03	62.0	64.0	CL	0.168	0.013	8.6	1.9

Notes: 'ft' = feet, USCS = Unified Soil Classification System, 'ksf' = kips per square foot

Parameter Definitions:

- CR = compression ratio (strain basis)
- RR = recompression ratio (strain basis)
- P'_c = estimated pre-consolidation pressure

- OCR = estimated over-consolidation ratio

5. Findings

Based on the results of our field exploration and laboratory testing programs, it is our opinion that there are no known geologic or geotechnical conditions that would preclude the design and construction of proposed project improvements. It is also our opinion that there are some geotechnical considerations that may affect design and construction of project elements described below:

- Undocumented fill materials were encountered in our subsurface exploration to depths ranging from approximately 0.5 to 2.5 ft below the existing ground surface. The term undocumented fill refers to human-made fill without documentation of engineering observation and testing during its placement. Undocumented fill is considered unsuitable to support project structures in its present condition unless documentation of its placement and compaction is reviewed or other studies are undertaken to assess the suitability and condition of the fill materials. Untested fill material should be removed from all areas of structural support.
- Based on the results of sampling and laboratory testing during construction, excavated and stockpiled undocumented fill materials generally may be used as project structural fill and backfill provided the materials meet the requirements in **Section 6.13.4** of this report. Stockpiled, on-site soils and import soils proposed for use as fill should be sampled and evaluated by the geotechnical consultant before use.
- Groundwater was not encountered in our exploratory borings along the pipeline alignment but was encountered in our explorations at the planned WTP site, with water observed at depths ranging from about 13 to 18 ft below the ground surface (El. 4,608 to 4,613 ft msl). Accordingly, some construction and excavation activities may be affected by groundwater (e.g., pumping or unstable subgrade, excavation dewatering, flowing sands, etc.) in some locations. Groundwater levels in nearby wells and piezometers can be monitored for changes in depth to groundwater prior to the start of construction to help assess the need for trench excavation dewatering. Installation of piezometers at the project site also should be considered so that periodic measurements of groundwater depth can be collected, leading up to construction.
- Based on our review of referenced geologic data and the distance to mapped faults and fissures, it is our opinion that the potential for fault-related surface rupture for project structures is low.
- Based on the soils encountered in our subsurface explorations, it is our opinion that structures may be supported by shallow strip footings or mat foundations. A factor of safety of 3.0 was used for recommended allowable bearing pressures. An allowable total settlement of 2 inches was considered for mat foundations and 1 inch for spread and strip footings. Detailed analyses and recommendations, including differential settlements and angular distortion of mat foundations, are presented in **Section 6.3.2** and **Section 6.4.2**.
- Based on our subsurface explorations, some of the project site is underlain by loose, wet, cohesionless silt and sand with relatively low penetration resistance. Accordingly, potential for some liquefaction induced settlement up to about 6 inches at the ground surface should be anticipated during a design seismic event. Liquefaction induced settlement is anticipated to occur primarily within soil layers between about 13 to 46 ft bgs. If estimated post-earthquake liquefaction settlements exceed design tolerances for Project facilities, liquefaction mitigation and/or ground improvement may be implemented to reduce or eliminate estimated liquefaction-induced settlement. More detailed discussion of post-earthquake liquefaction settlement and ground improvement alternatives is provided in **Section 6.5** and **Section 6.6**.
- Tested samples recovered from the exploratory borings have sulfate contents considered to be moderately deleterious to concrete; accordingly, concrete with Type II cement, a 4,500-psi design compressive strength, and a maximum water-cement ratio of 0.45 is recommended for concrete in

contact with on-site soils and for walls within 12 inches of finished grade. Recommendations for concrete and corrosion considerations are provided in **Section 6.11**.

- Tested soil samples indicate soil resistivity values considered highly to extremely corrosive to buried metal. Recommendations for buried metal are provided in **Section 6.11**.

6. Design and Construction Recommendations

The following sections provide our recommendations for design and construction of proposed project improvements based on our current understanding of the project, engineering properties of tested samples, geologic conditions presented in this report, and the assumption that an adequate number of tests and observations will be made during construction to evaluate compliance with these recommendations.

6.1 Seismic Design Parameters

The project site is at risk from ground shaking due to strong earthquake motions. Based on the results of subsurface investigations and field and laboratory testing performed, seismic Site Class D is considered appropriate for the project site in accordance with *ASCE/SEI 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 2017), adopted by Provo within the 2018 International Building Code (ICC 2017). Seismic structural design parameters are identified below, in **Table 6.1**, consistent with the generalized acceleration response spectrum procedure from *ASCE/SEI 7-16*. The seismic coefficients displayed in **Table 6.1** are applicable to an earthquake event having a return period of approximately 2,475 years, which is the building code requirement. Seismic design parameters were obtained from the ATC Hazards by Location website which uses the United States Geological Survey (USGS) Conterminous U.S. 2014 seismic source model or were developed directly from *ASCE/SEI 7-16*. As noted in **Table 6.1** (see note 2), special provisions apply relating to the calculation of the seismic response coefficient, C_s (due to seismic Site Class D and $S_1 > 0.2g$). A site-specific ground motion hazard analysis is not within the scope of this study; accordingly, the equivalent lateral force (ELF) procedure (Article 12.8 of *ASCE/SEI 7-16*) is assumed for use in structural design, and the seismic response coefficient C_s will be generated by Eq. (12.8-2) for values of $T \leq 1.5T_s$ and taken as equal to **1.5 times the value computed** in accordance with Eq. (12.8-3) for $T_L \geq T > 1.5T_s$ or with Eq. (12.8-4) for $T > T_L$.

Table 6.1 Summary of Seismic Design Parameters

Parameter	Value	Reference
Site Latitude	40.2620	Google Earth
Site Longitude	-111.6620	Google Earth
Site Class	D	ASCE 7-16 Article 20.3
PGA	0.63g	ATC Hazards by Location ¹
S_s	1.38g	ATC Hazards by Location ¹
S_1	0.51g	ATC Hazards by Location ¹
F_{PGA}	1.1	ASCE 7-16 Table 11.8-1
F_a	1.0	ASCE 7-16 Table 11.4-1
F_v^2	1.79 ²	ASCE 7-16 Table 11.4-2 ²
SDC	D	ASCE 7-16 Tables 11.6-1 and 11.6-2
PGA_M ($PGA \times F_{PGA}$)	0.70g	ASCE 7-16 Article 11.8.3
S_{MS} ($S_s \times F_a$)	1.38g	ASCE 7-16 Article 11.4.4

Parameter	Value	Reference
$S_{M1} (S_1 \times F_v)^2$	$0.92g^2$	ASCE 7-16 Article 11.4.4 ²
$S_{DS} (2/3 \times S_{MS})$	$0.92g$	ASCE 7-16 Article 11.4.5
$S_{D1} (2/3 \times S_{M1})^2$	$0.61g^2$	ASCE 7-16 Article 11.4.5 ²
$T_0 [0.2 \times (S_{D1}/S_{DS})]$	0.13 sec	ASCE 7-16 Article 11.4.6
$T_s (S_{D1}/S_{DS})$	0.66 sec	ASCE 7-16 Article 11.4.6
T_L	8 sec	ASCE 7-16 Article 11.4.6 and Figure 22-14

Notes:

1. Source: ATC Hazards by Location – <https://hazards.atcouncil.org/>
2. Given Site Class D with S_1 more than 0.2, additional requirement from Section 11.4.8 applies:
Ground motion hazard analysis is not required for structures other than seismically isolated structures and structures with damping systems where:
Structures on Site Class D sites with S_1 more than or equal to 0.2, provided the value of the seismic response coefficient C_s is determined by Eq. (12.8-2) for values of $T \leq 1.5T_s$ and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for $T_L \geq T > 1.5T_s$ or Eq. (12.8-4) for $T > T_L$.

6.2 Ductile Iron Water Main Pipeline

The following subsections present design and construction recommendations for the planned 36-inch-diameter finished water transmission pipeline that will extend southward along Freedom Boulevard from the southeast corner of the new WTP site and cross two parking areas as well as University Avenue to connect with existing water transmission infrastructure. The recommendations for the transmission pipeline are based on the geotechnical exploration completed along the alignment, our understanding of the proposed design, and anticipated construction methods.

6.2.1 University Avenue Crossing

Various installation methods were evaluated for the University Avenue transmission line crossing. Based on the proposed 36-inch diameter of the transmission pipeline, length of the crossing, and encountered subsurface soils in boring DH22-HDD-01, horizontal directional drilling, jack and bore techniques and traditional open cut trenching installation were considered. Of the trenchless methods, due to the short distance and adequate soil cover above the water table, jack and bore is anticipated to be more cost effective than HDD for trenchless installation. However, based upon current feedback from UDOT, who has jurisdiction for University Avenue, we understand that that cut-and-cover installation will be allowed with traffic lane closures and that cut-and-cover is planned since it is expected to be a less-costly method of construction for the crossing. Accordingly, trenchless pipeline design and construction recommendations are not presented herein.

6.2.2 Encountered Subsurface Soils and Conditions

Four borings were completed along the pipeline alignment near approximately stations 5+50 (DH22-explorationsP-03), 13+50 (DH22-P-02), 19+50 (DH22-HDD-01), and 27+00 (DH22-P-01). One additional boring was drilled approximately 150 ft west of Freedom Boulevard (DH22-WTP-01). The following sections describe subsurface soils and conditions encountered in the exploratory borings performed along the pipeline alignment.

6.2.2.1 Subsurface Soils

Subsurface soils encountered east of approximately Freedom Boulevard (approximately station 12+00) primarily consisted of medium stiff to stiff, low plasticity sandy silty clay (CL-ML) to sandy lean clay (CL) with varying amounts of fine sand and trace gravel. There were also occasional layers of nonplastic to low plasticity, loose to medium dense silty sand (SM) encountered, which ranged in thickness from 1 to 3 ft. At least one layer of silty gravel layer, approximately 2 to 3 ft thick, was encountered near the transmission pipeline's tie into the existing infrastructure near 150 E. Laboratory tested fine-grained soils indicate liquid

limits ranging from about 25 to 30 and plasticity indexes ranging from about 4 to 11; fines content of these layers typically exceeded 60 percent, and gravel content is generally less than 10 percent.

Subsurface soils encountered along Freedom Boulevard (new WTP site to approximately station 12+00) primarily consisted of nonplastic silty gravel (GM) to poorly graded gravel with sand (GP) overlain by several feet of silt, sand, and clay mixtures. There were also occasional cobbles encountered with individual particle diameters of up to 7 inches.

6.2.2.2 Groundwater

Groundwater was not encountered to the depth explored in the four soil borings along the project pipeline alignment; however, groundwater was encountered in explorations at the new WTP site between 13 and 18 ft bgs. Considering the primarily granular, cohesionless nature of existing site soils, groundwater level at the new WTP site is anticipated to be influenced significantly by the Provo River with diminishing influence farther from the river. Accordingly, groundwater should be anticipated during construction excavations along some portions of the pipeline alignment. Dewatering should also be anticipated during pipeline construction in some areas.

6.2.2.3 Concrete and Corrosion

Chemical tests and resistivity testing associated with the transmission pipeline were similar to those of the exploration at the new WTP site (see **Section 6.11**). Accordingly, the provisions and recommendations presented in **Section 6.11** are also applicable to the pipeline.

6.2.3 Trench Stability

The use of simple trench shoring, such as trench boxes and shields, is feasible for subsurface soils encountered east of approximately Freedom Boulevard (approximately station 12+00) to the planned depth of the pipeline invert (approximately 8 to 13 ft bgs). Because of the cohesionless nature of subsurface soils encountered along Freedom Boulevard (new WTP site to approximately station 12+00), the contractor should carefully evaluate the suitability of simple trench shoring prior to its implementation, including maintaining stability of the trench outside the shoring system to avoid undesirable impacts to adjacent utilities, pavement surfaces, or structures along that portion of the pipeline alignment. In the segment along Freedom Boulevard, vertical, or near vertical, excavation walls may be prone to raveling, instability, and collapse. Accordingly, trench excavation support, which may include the use of sloping (instead of benching), shoring, sheet piles, or secant piles, some combination of these systems, or other methods may need to be considered. A structural engineer experienced in retaining systems for temporary excavations should be consulted by the contractor during the design of a shoring system. The project's geotechnical engineer should review the design plans for a temporary retaining system prior to its implementation.

The contractor should protect all existing underground and overhead utilities and facilities and should conform with all laws and requirements governing the protection of underground utilities and facilities within the State of Utah, including all permit requirements of the Utah Department of Transportation (UDOT), Utah County, and the City within their respective jurisdictions. Consideration should be given to pipelines running parallel to the planned excavation. Trench excavations within two pipe diameters of existing pipelines and extending below the springline of, and running parallel to, existing pipeline utilities may need to be supported by properly designed trench shoring and bracing to prevent damage to existing pipelines or facilities.

Design and installation of utilities should accommodate the widespread difficult geotechnical conditions including shallow groundwater, soft soil bearing and long-term soil consolidation constraints, and loose liquefiable deposits (e.g., loose, saturated sands/gravels) with potential lateral spread, if encountered. Consideration should be given to ductile joints and connections, including recommended use of fully restrained joint systems where practical.

The purpose of dewatering during construction is to improve trench excavation wall and bottom stability, as well as subgrade stability, to facilitate pipeline installation. Dewatering in excavations is anticipated in some areas (see **Section 6.2.2.2**), to lower groundwater to about 2 ft or more below the bottom of the

anticipated excavations. Common dewatering methods may include sump pumping, well points, vacuum well points, or combinations of these. The contractor is responsible for the design, implementation, and operation of dewatering systems. The contractor should prepare a dewatering plan and, if applicable, a groundwater recharge plan, and submit to the engineer for approval prior to beginning excavation. Dewatering, if used, should be controlled and monitored to help reduce the potential for drawdown subsidence during construction, and dewatering effluent should be contained to avoid discharges into state receiving waters in accordance with applicable state and federal clean water regulations. A construction dewatering discharge permit may be needed, and water discharged during construction may require treatment, monitoring, sampling, and testing. Dewatering systems should discharge to an appropriate location, in accordance with permit requirements; surface water should be directed away from open trenches.

Trench dewatering and stability is the responsibility of the contractor. Accordingly, the contractor is responsible for the adequacy and safety of the means, methods and sequencing of trenching and pipeline installation. The contractor should also adhere to applicable Occupational Safety and Health Administration (OSHA) safety and industry standards. On-site safety of personnel will also be the responsibility of the contractor.

6.2.4 Trench Backfill

Trench backfill should generally comply with provisions put forth in Standard Detail P-255, Trench Backfill and Surface Restoration, of City Standard Drawing Details (PCPW 2022) and American Public Works Association (APWA) Standard Specifications (Utah APWA and Utah AGC 2017) as modified by City (PCPW 2022).

6.2.4.1 Bedding and Pipe Zone Backfill

Existing subsurface soils excavated east of approximately Freedom Boulevard (approximately station 12+00) or compacted Common Fill meeting requirements of Section 31 05 13 (Utah APWA and Utah AGC 2017) should provide suitable support for pipe bedding material. Existing subsurface soils encountered along Freedom Boulevard (new WTP site to approximately station 12+00) were silty to poorly graded gravels, which may be difficult to compact if disturbed. Accordingly, soils excavated on early portions of the transmission pipeline alignment may not be suitable as bedding support or trench zone backfill as discussed in **Section 6.2.4.2** and should be disposed of offsite by the contractor. Soils and fills used to support pipe bedding material should be moisture conditioned to within ± 2 percent of optimum moisture content (OMC) and compacted to 95 percent of maximum dry density (MDD) (ASTM Standard D1557-12 2021) in uncompacted lifts not exceeding 8 inches (6 inches for walk-behind equipment).

Bedding and pipe zone backfill, inclusive of haunching (backfill above the bedding and below the springline of the pipe) and backfill surrounding the pipe (backfill above the springline of the pipe to a minimum of 12 inches above the crown of the pipe), should be compacted sand meeting requirements of Section 31 05 13 (Utah APWA and Utah AGC 2017) as modified by City (PCPW 2022). The sand should be free of organics and should not contain pea gravel, recycled RAP, or crushed fines. The pipe bedding should be moisture conditioned and compacted to 90 percent of MDD (ASTM Standard D1557-12 2021) in uncompacted lifts not exceeding 8 inches (6 inches for walk-behind equipment). The thickness of bedding material should be 4 inches or more. For open cut excavations where the proposed transmission pipeline will bear at or near the current groundwater elevation, the soils at this depth are expected to lose stability due to construction activity. If the soils at the base of the pipeline excavations consist of higher clay content or looser sands, then it may be necessary to increase the thickness of the bedding layer to approximately 18 to 24 inches with geotextiles placed on the base of the trench and extending up to the spring line of the pipe, depending on the stability of the soil at the time of construction.

In areas underlain by silty to poorly graded gravels (new WTP site to approximately station 12+00) against which fine sands, silts, or clays are to be placed, a stabilization-separation geotextile should be used to prevent particle migration. The geotextile should extend along the bottom of the trench and extend vertically along the sides to the springline of the pipe. The geotextile should generally meet requirements of Section 31 05 19 (Utah APWA and Utah AGC 2017). The geotextile should be non-woven geotextile with an apparent opening size (AOS) of the No. 60 standard US sieve or finer, as needed.

6.2.4.2 Trench Zone Backfill

Some existing subsurface soils that will be excavated east of approximately Freedom Boulevard (approximately station 12+00) might meet the requirements for Borrow as specified in Section 31 05 13 (Utah APWA and Utah AGC 2017), as shown in **Table 6.2**, and could be used as trench zone backfill. Existing subsurface soils encountered along Freedom Boulevard (new WTP site to approximately station 12+00) were silty to poorly graded gravels, which may be difficult to compact, and at least one sample, silty sand (SM) encountered above the gravel in DH22-P-03, had organic content of nearly 30 percent. Such soils are unsuitable for use as trench backfill and should be disposed of offsite by the contractor. Particles larger than 2 inches should also be removed and disposed of offsite by the contractor. Imported fill meeting the requirements for Borrow, as specified in Section 31 05 13 (Utah APWA and Utah AGC 2017), or flowable fill, meeting requirements in Section 31 05 15 (Utah APWA and Utah AGC 2017), may be used as trench zone backfill. The trench zone backfill should be free of organics; relatively clean or uniformly graded gravels, pea gravel, or recycled RAP should not be used as trench zone backfill. Trench zone backfill should be moisture conditioned and compacted to 90 percent of MDD (ASTM Standard D1557-12 2021) placed in uncompacted lifts not exceeding 8 inches (6 inches for walk-behind equipment).

If flowable fill is to be used, material should flow easily requiring no vibration, and should be allowed to cure adequately before placing or compacting the pavement section. Flowable fills should have a design compressive strength of 60 pounds per square inch (psi), or more, in 28 days.

Table 6.2 Summary of Soil Properties for Tested Soils Encountered in Pipeline Borings

Boring (Approx. Station)	Sample Depth (ft)	Percent Passing			LL	PI	AASHTO Soil Classification	Meets Borrow Specification ¹
		No. 10	No. 40	No. 200				
DH22-P-01 (27+00)	3	88	84	63	24	7	A-4	Yes
DH22-P-01 (27+00)	8.5	0	99	79	23	5	A-4	Yes
DH22-P-02 (13+50)	3	100	100	92	29	10	A-4	Yes
DH22-P-02 (13+50)	10	100	100	91	27	7	A-4	Yes
DH22-P-02 (13+50)	14	100	99	93	30	11	A-6	No
DH22-P-03 (5+50)	4	61	51	31	32	7	A-2-4	No ²
DH22-P-03 (5+50)	14	22	17	8	--	--	A-1-a	Yes
DH22-HDD-01 (19+50)	6.5	100	99	83	23	5	A-4	Yes
DH22-HDD-01 (19+50)	14	100	100	88	25	6	A-4	Yes

Notes: LL = Liquid Limit; PI = Plasticity Index; AASHTO = American Association of Highway and Transportation Officials; '--' = not measured

1. Borrow as specified in Section 31 05 13 (Utah APWA and Utah AGC 2017) as modified by City (PCPW 2022).

2. Organic content for this sample was nearly 30 percent.

6.2.5 Transmission Pipeline Structures

Structural design and earthwork requirements for the transmission pipeline's appertaining structures (e.g., vaults) should follow the same guidance provided for new WTP structures (see **Sections 6.1, 6.2.5** through **6.8, 6.11**, and **6.13**).

6.2.6 Pavement Restoration

In areas where trench excavations extend through asphalt or Portland Cement concrete pavement (PCCP) sections, the pavement should be replaced to the full limits of damage if extending beyond the

trench cut, following City Public Works Standard Detail P-255, Trench Backfill and Surface Restoration (PCPW 2022).

6.3 Mat Foundations

Structures such as the basement level of the WTP, pump station, valve vault and diversion box are anticipated to have mat foundations. Accordingly, relevant design and construction recommendations appropriate for mat foundations are provided in the subsequent sections.

6.3.1 Bearing Capacity

The recommended allowable bearing capacities for foundations were calculated using dimensions and bearing elevations from preliminary drawings. Bearing capacities were evaluated under drained loading conditions for general bearing failure. The allowable bearing capacities are shown in **Table 6.3** and represent the total pressure applied to the structure foundation. The bearing capacity calculations were performed according to AASHTO LRFD Bridge Design Specifications (2017). A factor of safety of 3.0 was used for recommended allowable bearing pressures.

Settlement, which is presented in **Section 6.3.2** for mat foundations, was also considered while developing allowable bearing resistances. Long-term settlement that occurs under permanent or sustained static loads can result in significant settlement over time depending on the magnitude of the permanent load and the duration of the loading. The settlements discussed in **Section 6.3.2** are appropriate only for permanent bearing pressures that are less than the maximum permanent bearing pressures shown in **Table 6.3**, which, if exceeded, may result in more settlement than estimated in **Section 6.3.2**. Settlement estimates also are dependent on the bearing elevation for each structure. If the bearing elevation changes for a structure, the associated settlement also can change. Bearing capacity analysis results are provided in **Appendix F**.

Table 6.3 Bearing Resistance Analysis Input Parameters and Results

Structure Name	Foundation Dimensions [B x L] ³ (ft)	Anticipated Bearing Elevation ³ (ft)	Allowable Bearing Resistance (ksf)	Maximum Permanent Bearing Pressure (ksf)
Water Treatment Plant – Basement Level	120 x 120	4612.0	2.3 ²	1.5 / 2.3 beneath fluid tank
Pump Station	35 x 95	4612.0	2.9 ²	1.0
Valve Vault	17 x 17	4619.0	4.0	-- ⁴
Diversion Box	10 x 14	4618.0	4.0	1.0

Notes: 'ft' = feet, 'ksf' = kips per square foot

1. Water level was assumed to be at the El. 4,611 ft based on borings performed at the site.
2. Allowable bearing resistance was selected by limiting total settlement to about 2 inches – this includes immediate and primary consolidation settlement.
3. Settlement estimates are dependent on bearing elevation for each structure. If the bearing elevation changes for a structure, the associated settlement also may change.
4. Relatively low net loading is anticipated for the valve vault and diversion box and less than about 1 inch of settlement.

6.3.2 Settlement

Settle3 Version 5.0.15 (Rocscience, 2022) was used to estimate total settlements due to foundation loading based on a one-dimensional analysis, which considers immediate elastic settlement and primary consolidation of subsurface materials. Immediate settlement is the settlement that is anticipated to mostly occur immediately upon loading and construction; primary consolidation is the result of the expulsion of air and water out of the soil matrix and generally takes a longer time to progress. Vertical induced stresses were calculated using the Boussinesq (1883) flexible foundation methods implemented in the

Settle3 software. Soil compressibility parameters were based on the conditions encountered in the exploratory borings and the laboratory testing results.

Estimated settlement, differential settlement, and angular distortion for the WTP facilities that are supported on mat foundations are summarized in **Table 6.4**. Data from the settlement analysis are provided in **Appendix F**.

Table 6.4 Settlement and Angular Distortion of Mat Foundations

Structure	Maximum Estimated Settlement (inches)	Estimated Settlement at Corner of Mat (inches)	Differential Settlement (inches) / Distance (ft)	Angular Distortion (radians)
Water Treatment Plant – Beneath Fluid Tank	2.0 ¹	1.3	0.7/ 51	0.001
Water Treatment Plant –Basement	1.8 ¹	1.1	0.7/ 58	0.001
Pump Station	1.0 ¹	0.7	0.3/ 40	0.001
Diversion Box	0.2 ¹	0.2	0	0

Notes: 'ft' = feet

1. Estimated settlement shown represents both immediate and long-term settlement. Immediate settlement is estimated to be about one half of the total settlement reported and is anticipated to occur during construction and commissioning of project structures. Long-term settlement is estimated to be about one half of the total settlement reported and is anticipated to occur over time during the design life of the facility.
2. Water level was assumed to be at the El. 4,611 ft based on borings performed at the site.
3. Settlement reported here is estimated using field and laboratory data.

Settlement estimation often is imprecise, and soil conditions are assessed based on limited points of investigation, limited soil samples, and limited laboratory testing. Estimates of settlement in this report may be more or less than actual settlements, and the locations of maximum settlement may vary. Estimated settlement and tolerable settlement for structures, based on information provided by the structural engineer, were considered in developing allowable bearing capacity in the following sections.

6.4 Spread and Strip Footings

The upper level of the WTP and the first floor of the pump station can be supported by shallow strip footings. The clearwell tanks can be supported on shallow spread footings. Accordingly, design and construction recommendations appropriate for spread and strip footings are provided, based on structural plans.

6.4.1 Frost Depth and Foundation Embedment

Consistent with the IBC (ICC 2017) and local practices, the minimum foundation embedment recommended for exterior structure and wall foundations is 30 inches, which represents the depth from the bottom of the foundation to the lowest adjacent final grade.

6.4.2 Bearing Capacity and Settlement

The recommended allowable bearing capacity, which considers an allowable settlement up to 1 inch, for strip footings supporting the upper level of the new WTP, the clearwell walls, and the first floor of the pump station is 4 kips (one kip is one thousand pounds) per square foot (ksf). Applying this to footing widths from 2 to 4 ft results in an allowable strip load of 8 to 16 kips per lineal foot (klf). This recommendation was developed based on our understanding of the preliminary foundation loads and anticipated embedment depth.

The recommended allowable bearing capacity, which considers an allowable settlement up to 1 inch, for spread footings supporting the clearwells is 4 ksf; this applies to footing widths ranging between 4 to 9 ft. This recommendation assumes that the footings are bearing near El. 4,612 ft.

Bearing capacity and settlement estimates are dependent on the bearing elevation for each structure. If the bearing elevation, load, or width of the strip footing changes, the associated settlement could also change. The settlement and bearing capacity analysis results are provided in **Appendix F**.

6.5 Post-Earthquake Liquefaction Settlement

Post-earthquake liquefaction settlement was estimated for facilities located at the treatment plant site. Exploratory borings and CPTs advanced at the treatment plant site encountered some wet, cohesionless sand and silt layers with field blow counts, *N*, as low as 6 with apparent individual layer thicknesses of about 2 to 10 ft at depths ranging from 13 to 57 ft bgs corresponding to El. 4,569 to 4,612 ft (primarily between 13 to 46 ft bgs, corresponding to El. 4,578 to 4,612 ft). Liquefaction triggering and settlement analyses were performed following the methodology of Idriss and Boulanger (2008) as modified by Boulanger and Idriss (2014) and Ishihara and Yoshimine (1992). Post-earthquake liquefaction settlement estimates are summarized in **Table 6.5**. The results of the liquefaction settlement analyses suggest the potential for post-liquefaction settlements of approximately 3 to 6 inches for the design seismic loading. Based on this assessment, extreme event post-liquefaction settlements on the order of 6 inches should be considered in the design of project structures and utilities unless mitigation efforts are implemented to help reduce the potential for liquefaction to occur (e.g., removal of susceptible layers, ground improvement) or to help reduce the associated post-liquefaction settlement (selecting a deep foundation system to extend below the susceptible layers). It is anticipated that ground improvement might be preferred over deep foundation systems; some ground improvement alternatives are discussed in **Section 6.6**.

Table 6.5 Summary of Post-Earthquake Liquefaction Settlement Estimates

Exploration ID	Exploration Depth (ft)	Estimated Post-Earthquake Liquefaction Settlement (in) ¹	Nearest Structure/Facility
DH22-HDD-01	43.0	-- ²	Transmission Pipeline near HDD crossing Under University Avenue
DH22-P-01	18.0	-- ²	Transmission Pipeline Near 150 East Street
DH22-P-02	18	-- ²	Transmission Pipeline from Freedom Boulevard to University Avenue
DH22-P-03	16.1	-- ²	Transmission Pipeline Under Freedom Boulevard
DH22-WTP-01	118	3.8 ³	Water Treatment Plant
DH22-WTP-02	80	4.9 ³	Clearwell East, Pump Station, Valve Vault
DH22-WTP-03	81	3.0 ³	Clearwell West, Drain Vault
CP22-WTP-01	120.1	2.6 ³	Water Treatment Plant
CP22-WTP-02	74.8	3.5 ³	Clearwell East, Pump Station, Valve Vault
CP22-WTP-03	121.3	4.0 ³	Clearwell West, Drain Vault
CP22-WTP-04	71.2	4.7 ³	Water Treatment Plant, Clearwell West
CP22-WTP-05	81.0	3.7 ³	Water Treatment Plant, Diversion Box
CP22-WTP-06	74.2	3.3 ³	Water Treatment Plant

Notes: 'ft' = feet

1. Post-earthquake liquefaction settlement estimate based on Boulanger and Idriss (2014) using SPT (measured and inferred) blowcounts from exploratory drill hole advanced using sonic methods.
2. Saturated groundwater conditions not encountered during drilling of the given exploration. Saturated conditions could exist at deeper depths.

Exploration ID	Exploration Depth (ft)	Estimated Post-Earthquake Liquefaction Settlement (in) ¹	Nearest Structure/Facility
3.	Due to conditions during drilling of borings or pre-drilling for CPTs, SPT sampling or CPT sounding was not able to be performed in the upper 1-4 ft of the liquefaction-susceptible materials. Accordingly, slightly more post-earthquake liquefaction settlement than the reported estimates could occur (an additional 1 inch, or so, totaling up to approximately 3 to 6 inches).		

Groundwater and saturated conditions were not encountered in the four exploratory borings performed for this study along the proposed pipeline alignment; the borings along the alignment extended to depths ranging from 16 to 43 ft bgs. Accordingly, some conditions needed for liquefaction were not encountered to the depths explored along the proposed pipeline alignment. Between Freedom Blvd and 150 East Street, the existing ground surface is approximately 10 to 25 ft higher in elevation and farther from the Provo River than the segment along Freedom Blvd. Elevation and proximity to the Provo River may influence the potential for saturated, loose, and cohesionless materials susceptible to liquefaction that could exist between, beyond, or below the explorations performed along the proposed pipeline alignment. If materials susceptible to liquefaction are present along the alignment below the depth explored and post-earthquake liquefaction settlement was to occur in a seismic event, it is anticipated that the magnitude of settlement could be less than that estimated to occur at the treatment plant site. However, considering that explorations along the pipeline alignment were relatively shallow, the proposed pipeline should be designed to accommodate some liquefaction-induced settlement that could occur during an earthquake event. The results of the liquefaction analysis are presented in **Appendix E**.

6.6 Ground Improvement Alternatives

If estimated post-earthquake liquefaction settlements exceed design tolerances for Project facilities, liquefaction mitigation and/or ground improvement is recommended to reduce or eliminate estimated liquefaction-induced settlement. Based on the elevation range in which potentially liquefiable soils were encountered, as discussed in **Section 6.5**, it is anticipated that if suitable ground improvement using established industry methods is performed between El. 4,578 to 4,612 ft, post-earthquake liquefaction settlement could be reduced to less than about 1 inch. For such an improved ground condition, it is anticipated that essentially no post-earthquake liquefaction settlement would be anticipated within the treated area. Beyond any area of ground improvement, post-earthquake liquefaction settlement should still be expected; differential settlement near the perimeter of an area of ground treatment will need to be accommodated in design of appurtenant structures, utilities, connections, etc.

Ground improvement alternatives may be proposed by the contractor; however, some ground improvements are anticipated to be more effective for the site conditions dealing with the gravel and cobble overburden, such as rammed aggregate piers or stone columns. Rammed aggregate piers form a densified column of aggregate surrounded by a stiffened soil matrix and can be installed by several open hole and cased methods to depths of up to about 35 ft. Stone column ground improvements use a down-hole vibrating probe suspended from a crane to displace and open a space in the soil column and fill it with aggregates that are densified with the surrounding matrix soil by vibrating the probe. Stone columns can be formed to deeper depths than rammed aggregate piers, particularly where crane equipment is used. Other methods such as soil cement mixing and rigid inclusions could be used but will require significant predrilling or additional excavation.

Acceptance of ground improvements proposed by the contractor to mitigate liquefaction at the project site will need to be based on review of the proposed construction alternative and confirmation of the installed solution to meet performance requirements. A performance specification is planned to be included in the construction documents to provide the ground improvement specialty contractor with guidelines and criteria to meet, such as: a zone of treatment that extends beyond the footprint of proposed structures, a zone of treatment that extends down to El. 4,578 ft (to penetrate through the depths where liquefiable soil layers are anticipated), and an adequate distribution of the treatment method (e.g., spacing and effective diameter of aggregate piers/columns) to meet specified settlement performance criteria and the intent of the design.

6.7 Lateral Earth Pressures and Sliding

Design of earth-retaining and buried structures should consider lateral earth pressures (LEP) presented in this section. These recommendations are based on consideration of existing materials at the site along with anticipated fill materials (that are placed and compacted adjacent to structures).

Typically, the resulting LEP distribution for soils is assumed to increase linearly from the ground surface (top of the soil adjacent to the wall or foundation) to the base of the wall or foundation. To facilitate the application of this pressure distribution in design, recommended lateral-earth equivalent-fluid weights are presented in **Table 6.6**. Lateral-earth equivalent-fluid weights represent the equivalent-fluid weight (analogous to water pressure) resulting from LEP in the various retaining cases. Lateral-earth equivalent-fluid weights may be used to develop the pressure distribution with depth resulting from retained soils. The provided equivalent-fluid weights do not account for any water pressure that may build up behind a wall. Accordingly, when water pressures are anticipated to be present during the design life of the structure, static water pressure should be added to the earth pressures obtained from the equivalent-fluid weights presented in **Table 6.6**. For relatively rigid, buried structures, or for restrained walls, the at-rest equivalent-fluid weights (static and seismic components) should be used.

The seismic component of the equivalent-fluid weights listed in **Table 6.6** are the pseudostatic component of the seismic earth pressure, rather than the combined static and seismic LEP; accordingly, the static equivalent-fluid weight (i.e., either the active or at-rest value) should be added to the seismic equivalent-fluid weight shown in the table for the combined effect. For the passive earth case, the seismic component of the equivalent-fluid weights will reduce the static passive earth pressure equivalent-fluid weight. The results of the LEP analysis are provided in **Appendix G**.

A certain amount of movement is required to mobilize active and passive earth pressure. The amount of movement required to mobilize earth pressure can be expressed as the ratio of the movement at the top of the wall, Δ , to the height of the wall, H . It is recommended that values of Δ/H of 0.002 and 0.02 be used for mobilization of active and passive pressure, respectively, for granular backfill. We recommend that values of Δ/H of 0.01 and 0.05 be used for mobilization of active and passive pressure, respectively, for silt or clay material. Linear development of earth pressure should be assumed. Where such deflection is deemed unacceptable, at-rest pressures should be used in place of active/passive earth pressures.

Table 6.6 Summary of Recommended Lateral Earth Equivalent-Fluid Weights

Location	Load Case	Active ¹ [Submerged ²] (pcf)	At-Rest ¹ [Submerged ²] (pcf)	Passive ¹ [Submerged ²] (pcf)
Project Site (El. 4,630 to 4,570 ft)	Static	45 [25]	75 [40]	490 [225]
	Seismic Component ³ (Pseudostatic)	50 [25]	60 [30]	-125 [-60]

Notes: pcf = pounds per cubic foot

1. Equivalent-fluid weights for passive and at-rest/active earth pressure are calculated using assumed soil unit weights of 135 pcf for at-rest/active and 115 pcf for passive. Earth pressure coefficients may be calculated by dividing the equivalent-fluid weight by the assumed soil unit weight.
2. Submerged unit weights only account for pressure from soil and are appropriate for use where the surrounding soil is submerged; submerged equivalent fluid pressures do not include water pressures, which will need to be added to the pressure shown.
3. Lateral earth equivalent-fluid weights for the seismic components are based on a horizontal seismic coefficient equal to half of the peak ground acceleration (see **Section 6.1**) for the active and passive conditions.

Backfill placed behind retaining walls or subsurface walls should meet material and placement recommendations for structural fill presented in **Sections 6.13.4** and **6.13.5**. Over-compaction adjacent to retaining walls or subsurface walls should be avoided; recommended LEPs assume that compaction behind retaining walls or subsurface walls will be accomplished with relatively light compaction equipment.

Sliding resistance is estimated using a ratio of normal stress to shear resistance for an interface between concrete and the soil upon which the concrete is bearing. A friction ratio (τ/σ_n) of approximately 0.4 should

be used for sliding resistance, assuming that the concrete is bearing on granular backfill. Because the displacement required to mobilize ultimate passive earth pressure conditions can be substantial, the passive earth pressure contribution to sliding resistance should be neglected. If passive resistance is considered, the passive resistance should be implemented per the recommendations in this section.

6.8 Floor Slabs and Coefficient of Subgrade Reaction

Concrete slab-on-grade floors (including jointing and reinforcement) should be designed by the project's structural engineer based on anticipated loading conditions. Conventional concrete slab-on-grade floors should be founded on approximately 6 inches of untreated base course (UTBC) compacted to 95 percent or more of the laboratory maximum dry density, as evaluated by ASTM D1557. For concrete slab-on-grade design, an average modulus of subgrade reaction, k , of 175 pounds per cubic inch (psi/in) is recommended.

Floor slabs should be 4 inches or more in thickness and reinforced to control cracking. As a minimum, No. 3 steel reinforcing bars placed at 24 inches on-center both ways, placed at mid-height within the slab should be considered (masonry or plastic "chairs" should also be considered to aid in the placement of the reinforcement). Final slab thickness and reinforcement should be recommended by the project structural engineer. To help reduce shrinkage cracks, conventional slab-on-grade floors should include control joints in accordance with the recommendations of a qualified structural engineer.

Floor slabs should be separated from bearing walls and columns with expansion joints which allow unrestrained vertical movement. Joints should be observed periodically, particularly during the first several years after construction. Slab movement can cause previously free-slipping joints to bind. Measures should be taken so that slab isolation is maintained in order to reduce the likelihood of damage to walls and other interior improvements.

As an alternative to slab reinforcement with steel reinforcing bars, post-tensioned slabs designed by a qualified structural engineer may be considered. Geotechnical recommendations for design of post-tensioned slabs-on-grade will be provided upon request.

A 10-mil or thicker polyethylene (or equivalent) membrane should be used. Such a membrane is typically placed beneath the slab and over the UTBC and overlain by an additional 2 inches of sand or fine gravel (the overlying granular material can help to protect the membrane from puncture during placement, to aid in concrete curing, and help control slab curl). The project structure designer or architect should design and detail any such moisture control systems and their applications, such as in areas where moisture sensitive flooring is used or where mold or musty smells are not wanted.

6.9 Frost Depth

Shallow foundations for the project should be embedded a minimum of 30 inches below the adjacent ground surface (measured to the base of the footing from the lowest, adjacent, exterior ground surface) to help reduce movement associated with freeze-thaw cycles and frost heave.

6.10 Concrete Flatwork

Ground-supported flatwork, such as walkways, may be subject to soil-related movements resulting from heave/settlement, frost, etc. Accordingly, where these types of elements abut rigid building foundations or isolated/suspended structures, differential movements should be anticipated. Flexible joints should be provided where such elements abut the WTP structures to allow for differential movement at these locations.

Exterior concrete flatwork should be supported on properly prepared subgrade, as described in **Section 6.13.2** of this report, overlain by 4 or more inches of UTBC compacted to 95 percent or more of the laboratory maximum dry density, as evaluated by ASTM D1557. Positive drainage should be established and maintained adjacent to flatwork. Water should not be allowed to pond on or adjacent to flatwork.

Exterior flatwork should not extend under any portion of the building where there is less than 2 inches of vertical clearance between the flatwork and any element of the building. Exterior flatwork in contact with brick, rock facades, or any other element of the building can cause damage to the structure when differential movements occur between the flatwork and structure.

Prior to placement of flatwork, a proof roll should be performed to evaluate areas that exhibit instability and deflection. The soils in these areas should be removed and replaced with engineered fill or be stabilized according to recommendations presented in **Section 6.13.3**.

6.11 Concrete and Corrosion Considerations

Chemical tests and resistivity testing associated with this study were performed. Based on the results of the chemical testing, some of the tested on-site soils indicate negligible to moderate sulfate exposure, as described in the American Concrete Institute (ACI) manual, Section 318R-14 (ACI, 2017). In addition, concrete at the site is anticipated to be exposed to freezing-and-thawing cycles with relatively frequent exposure to water. Accordingly, concrete in contact with on-site soils, along with walls up to 12 inches above finished grade, should contain Type II cement, have a design compressive strength of 4,500 psi, and a maximum water-cement ratio of 0.45. The maximum water-soluble chloride ion content in concrete should be limited in accordance with ACI 318-19 Table 19.3.3.1 (considering F2 or F3 exposure class). Chloride content of tested soils was relatively low (less than 431 ppm); however, if concrete is expected to be exposed to de-icing salts, it is recommended that a maximum water-cement ratio of 0.40 be used with a design compressive strength of 5,000 psi or more. In addition, concrete cover and slump should be specified by the structural engineer of record, and good densification procedures should be used during placement, to reduce the potential for honeycombing.

Based on the results of the chemical testing, samples recovered in some exploratory borings have tested chloride levels less than 500 ppm, which suggests specific corrosion mitigation methods based on chloride levels are not needed. However, resistivity tests performed during this study indicate fully saturated, laboratory resistivity values ranging from 610 to 1,930 ohm-centimeters. This is considered severely corrosive to metal. Accordingly, corrosion reduction methods should be considered for this project, especially when designing buried metal pipes. These corrosion reduction methods might include bonded dielectric protective coatings, electrical isolation from connecting pipelines, pipe sleeving, and/or appropriate cathodic protection as recommended by a qualified corrosion engineer. Where permitted by jurisdictional building codes, the use of plastic pipes for buried utilities should also be considered.

6.12 Demolition

Construction of proposed project improvements will include demolition of existing asphalt pavements and might include removal or relocation of some existing utilities. Remnants from demolished structures and pavements should be removed from the project site with a minimum disturbance to the underlying soils unless directed by contract documents. The contractor should take adequate precautions when grading and excavating to reduce the potential for damage to utilities that need to remain in service. The project's geotechnical consultant should observe demolition activities to evaluate whether demolished structural materials and utilities are adequately removed, and that the resulting excavations are adequately backfilled. Disturbed soils should be removed or prepared and properly compacted (providing they meet backfill requirements) prior to placing any new structural fill, pavement base, or pavement materials.

6.13 Earthwork

The following sections provide our recommendations for earthwork, including excavations, site grading, subgrade stabilization, structural fill and backfill, and fill placement and compaction. Our recommendations are based on our evaluation of information obtained from five exploratory borings and associated laboratory testing performing for this study, our observations while at the project site, and our experience with similar materials. Earthwork operations should be performed in accordance with applicable codes, safety guidelines, and other city, county, state and federal guidelines.

6.13.1 Excavations

In our opinion, the site soils may generally be excavated with heavy-duty earthmoving or excavation equipment in good operating condition. Excavated materials might include undocumented fills and or/native soils (including sands, gravel, silts, and clays). When nearing excavation bottoms, equipment and procedures that do not cause significant disturbance to the excavation bottoms should be used, as feasible. Excavators with buckets having large claws to loosen the soil should be avoided when excavating the bottom 6 to 12 inches of the excavation, as such equipment may disturb the excavation base.

Groundwater was encountered in some of our exploratory borings at depths ranging from about 13 to 18 ft, corresponding to approximately El. 4,608 to 4,613 ft. It is anticipated that project improvements, including facilities at the water treatment plant site, will require excavations to elevations below the observed groundwater level (see also **Section 6.2.2.2** and **Section 6.2.3**). Accordingly, groundwater should be considered during design and for construction of project improvements. Installation of piezometers at the project site prior to the start of construction should be considered so that depth to groundwater can be periodically measured and the data made available to the contractor.

Yielding/pumping subgrade conditions may be encountered in some excavations. Incorporation of subgrade stabilization measures, limiting rubber-tire equipment access, etc. may be needed in areas of yielding subgrade. In addition, because anticipated groundwater depths are shallower than proposed excavations, dewatering measures should be considered during design, construction, and operation of project improvements.

The contractor should construct the sides of excavations at a safe and stable slope condition in accordance with current OSHA guidelines or provide an appropriately designed and constructed braced-shoring system; shoring should follow current OSHA guidelines, for employees working in an excavation where they could be exposed to dangers of moving ground. If material is stored or equipment is operated near an excavation, additional pressure due to superimposed loads should be considered in the shoring design. Water should not be allowed to flow over the top of an excavation in an uncontrolled manner.

Excavation dewatering and stability are the responsibility of the contractor. Accordingly, the contractor is responsible for the adequacy and safety of the means, methods, and sequencing of excavations. The contractor should adhere to applicable Occupational Safety and Health Administration (OSHA) safety and industry standards. On-site safety of personnel will also be the responsibility of the contractor.

Undocumented fill materials in their current condition should not be considered suitable to support project structures. Four exploratory borings performed for this study encountered undocumented fill at depths ranging to about 2 ft. The full depth of any on-site undocumented fill and surficial loose and/or disturbed native soils should be removed from proposed structure and other improvement areas including building, block screen/retaining wall, pavement, and exterior concrete flatwork areas. These excavated soils may be processed and stockpiled for later use as structural fill or backfill if they comply with the recommendations provided in this report.

6.13.1.1 Dewatering

Groundwater was observed at depths shallower than some of the anticipated excavation depths. Dewatering of excavations, or other means of mitigating the effects of groundwater, including flowing sands, should be anticipated during earthwork operations, where excavations extend near or below anticipated groundwater. In addition, based on the depth of groundwater encountered in our subsurface explorations and the planned basement elevations of the proposed below-grade structures, it is our opinion that long-term exposure of subsurface structures to infiltration of groundwater should be anticipated. Measures should be taken to adequately drain and convey groundwater away from below-grade structures. These measures may include sump pumps and waterproofing the subsurface portions of the structure to mitigate potential groundwater infiltration. When construction dewatering is anticipated, permitting for discharge of pumped groundwater could be needed.

The purpose of dewatering is to improve excavation wall and bottom stability, as well as subgrade stability, and to allow installation of subsurface improvements and compaction of structural fill. Dewatering measures may include installation of well points, deep wells, and other devices. The scope of our study did not include performance of a hydrogeologic study, design of a dewatering program, nor applying for a dewatering permit for this project. Upon request, we can prepare a proposal for a dewatering study and/or preparation of a dewatering permit application for this project.

Existing structures or utilities within the limits of groundwater drawdown resulting from dewatering might experience settlement during dewatering activities. The amount of settlement, if it occurs, will depend primarily on the amount and duration of the dewatering and subsurface soil conditions. Consideration should be given to monitoring nearby facilities for possible movement and associated damage during dewatering operations. If movement occurs, or if damage is observed, dewatering operations should be temporarily suspended, and the project's geotechnical consultant/owner's representative should be informed. Recommendations for mitigating settlement and associated distress should be provided by the geotechnical consultant/owner's representative.

6.13.2 Site Grading

Prior to grading, proposed structure and improvement areas should be cleared of any pavements, surface obstructions, debris, organics (including vegetation), and other deleterious material. Materials generated from clearing operations should be removed from the project site for disposal (e.g., at a legal landfill site). Obstructions that extend below finish grade, if present, should be removed and resulting voids filled with compacted soil or cement slurry, in accordance with the recommendations of the geotechnical consultant. Topsoil present on-site should not be incorporated into engineered fill but may be stockpiled for re-use as landscaping material or other non-structural material.

The geotechnical consultant should observe areas to receive fill at the time of grading to assess the suitability of the exposed material and to evaluate if removals down to more competent soils are needed. After the removals described above have been made and prior to foundation preparations or additional fill placement, the exposed native materials should be scarified to approximately 6 inches, moisture-conditioned to within +/-2 percent of OMC and compacted to 95 percent MDD (ASTM Standard D1557-12 2021).

6.13.3 Subgrade Stabilization

Subgrade stabilization will be needed where unstable (pumping) subgrade conditions are encountered. Pumping conditions may occur where excavations extend near to or below groundwater. Stabilization methods should be provided by the grading contractor, as needed, and may include the use of a geogrid, such as Tensar TX160, or a woven geotextile fabric, such as Mirafi 600X, placed on unstable subgrade and overlain by 12 inches of crushed rock or Aggregate Base. Pushing oversized angular rock, up to approximately 6 inches in nominal diameter, into exposed unstable subgrade soils may also be an appropriate stabilization alternative. The volume of rock needed will vary based upon factors including the moisture content of the native soil, soil type, depth to groundwater, and total affected area. Placement of angular rock should continue until the area exhibits a relatively non-yielding behavior as observed or tested by the geotechnical consultant.

If conditions (e.g., excavations extending below groundwater) are observed that indicate additional stabilization efforts may be needed, a combination of over-excavation, rock fill, and geogrid placement should be considered. Dewatering and use of relatively light or tracked equipment may also be needed. The geotechnical consultant/engineer during construction should evaluate proposed subgrade stabilization methods prior to their implementation.

6.13.4 Structural Fill and Backfill

Structural fill and backfill soil should consist of well graded, coarse-grained material (a relatively even distribution of grain sizes with 50 percent or more retained on the No. 200 sieve), a low plasticity index (less than 10), a sulfate content less than 0.2 percent, and chlorides less than 500 ppm. Structural fill and

backfill soils should have an expansion index (EI) less than 50 and be free of organic material, clay lumps, claystone bedrock fragments, construction debris, rock particles, other deleterious matter, or rocks or hard chunks larger than approximately 2 inches nominal diameter unless directed by the geotechnical consultant.

Fragments of rock, cobbles, and inert construction debris (e.g., concrete or asphalt) larger than 2 inches in dimension should be specially handled prior to incorporating them into project fills. AECOM should be consulted regarding appropriate recommendations for use of such materials on a case-by-case basis when such materials are encountered during earthwork.

6.13.5 Fill Placement and Compaction

Following site excavations and prior to the placement of engineered fill, the resulting exposed surfaces should be carefully evaluated by the geotechnical consultant. This evaluation may include proof-rolling, soil probing, visual assessment and/or additional laboratory testing. Based on this evaluation, additional remediation may be needed, which could include additional improvement of the exposed surface. This additional remediation (if needed) should be resolved by the geotechnical consultant during the earthwork operations. Fill should not be placed on pumping subgrades. Also, fill materials should not be placed, worked, or rolled while they are frozen or thawing, and should not be placed during poor/inclement weather conditions.

Preparation of subgrade surfaces in areas to receive fill or that will have structures bearing on them should include scarification and moisture-conditioning to a depth of approximately 6 inches, and compaction to a relatively nonyielding condition, prior to placement of fill.

Soils used as structural fill and backfill should be moisture-conditioned to within ± 2 percent of OMC and placed and compacted in uniform horizontal lifts to 95 percent of MDD (ASTM Standard D1557-12 2021). The optimal lift thickness of fill will depend on the type of soil and compaction equipment used. All types of compaction equipment have a depth of influence; hence the maximum appropriate thickness of a lift of fill depends upon the type of equipment used. For light, hand-operated equipment such as vibratory plate and "jumping jack" compactors (or for fills placed in confined areas), the maximum uncompacted lift thickness is commonly 4 inches. For small trench compactors, the maximum uncompacted lift thickness is commonly 4 to 6 inches depending on the size of the compactor. For larger compactors, the thickness of fill lifts should be limited to 8 inches of uncompacted material. The minimum thickness of lifts should also generally be at least twice the dimension of the largest particle size of the fill material.

If fill material is placed where the existing ground surface is steeper than 5H:1V, the surface on which fill is to be placed should be benched. Benches should be 8 ft wide, or more, or be of sufficient width to permit operation by compaction equipment. Benches should include approximately 2-foot high vertical or near-vertical intervening steps, cut to expose medium dense to very dense soil as evaluated in the field by the geotechnical consultant during earthwork operations.

Earthwork operations should be observed and compaction of structural fill and backfill materials should be tested by the project's geotechnical consultant. Typically, one field test should be performed, per lift, for each approximately 500 cubic yards of fill placement in structural areas and every 500 linear ft of trench backfill. Additional field tests may also be performed in structural and non-structural areas at the discretion of the geotechnical consultant or the direction of the building official. Compaction areas should be kept separate, and no lift should be covered by another until relative compaction and moisture content within the recommended ranges are obtained.

6.14 Utility Installation

The contractor should provide adequate mechanical compaction in utility trench backfills, consistent with the moisture conditioning and compaction required for structural fill and backfill in **Section 6.13.5**. The contractor should take particular care to achieve and maintain adequate compaction of the backfill soils around manholes, valve risers and other vertical pipeline elements where settlements are commonly observed. Use of "flowable fill," (e.g., a controlled low strength mix, CLSM, or a similar material) may be

considered in lieu of compacted soil backfill for areas with low tolerances for surface settlements in deep excavations and areas with difficult access.

Pipe bedding materials, placement and compaction should meet the specifications of the pipe manufacturer and applicable municipal standards. Materials proposed for use as pipe bedding should be tested for suitability prior to use.

Special care should be exercised to avoid damaging the pipe or other structures during the compaction of trench backfill materials. In addition, the underside (or haunches) of the pipe should be supported on bedding material that is compacted as described above. This may need to be performed with handheld compaction equipment or small-scale mechanical compaction equipment.

Sandy pipe bedding materials can function as conduits for re-distribution of natural and applied waters in the subsurface. Development of site grading plans should consider the subsurface transfer of water in utility trenches and the pipe bedding in areas where the utility trenches penetrate the building footprint. Cut-off walls in utility trenches or other water-stopping measures should be considered to help reduce the rates and volumes of water transmitted along utility alignments and transmitted toward the proposed building, or other structures; wetting of soils near structures can increase the potential for soil movements, material degradation, and structural distresses. Incorporation of water cut-offs and/or outlet mechanisms for saturated bedding materials into development plans should be considered for the project. Cutoffs and outlet mechanisms will help reduce the potential for migration of fines into the bedding and subsequent, associated settlement.

To help reduce the risk of damage to utilities due to long-term settlement or seismic ground motions, flexible connections for utility-structure connections should be considered. In addition, to help limit effects of differential settlement, permanent pipe connections should be made as late as practical in the construction sequence. Making pipe connections late in the construction process will allow some long-term permanent settlement from new structure loads to occur before pipe connections are made.

6.15 Site Drainage

Infiltration of water into subsurface soils can lead to soil movement and associated distress, and chemical and physical deterioration of concrete structures. To help reduce the potential for infiltration of moisture into subsurface soils at the site, the following should be considered:

- Positive drainage should be established and maintained away from the proposed building(s). Positive drainage may be established by providing a surface gradient for paved areas of 2 to 5 percent or more for a distance of 10 ft or more away from structures. For unpaved areas, positive drainage may be established by a slope of 5 to 10 percent for 10 ft or more away from structures, where possible.
- Adequate surface drainage should be provided to channel surface water away from on-site structures and off paved surfaces to a suitable outlet such as a storm drain or infiltration basin. Adequate surface drainage may be enhanced by utilization of graded swales, area drains, and other drainage devices. Surface run-off should not be allowed to pond near structures or structure footings.
- Building roof drains should have downspouts tight lined to an appropriate outlet, such as a storm drain or the street. If tight lining of the downspouts is not practicable, they should discharge 5 ft or more away from structures and onto surfaces that slope away from the structure. Downspouts should not be allowed to discharge onto exposed ground surface adjacent to building foundations.
- Downspouts should discharge to drainage systems away from structures, pavements, and flatwork. Incorporating a perimeter drainage system around the building foundations that will aid in reduction of moisture infiltration into subsurface soils might need to be considered.

6.16 Scaling

Climatic conditions in the project area including relatively low humidity, large temperature changes and repeated freeze-thaw cycles, may cause surficial scaling and spalling of exterior concrete. Occurrence of

superficial scaling and spalling can be aggravated by poor workmanship during construction, such as “over-finishing” concrete surfaces and the use of de-icing salts on exterior concrete flatwork, particularly during the first winter after construction. The use of de-icing salts on nearby roadways, which can be transferred by vehicle traffic onto newly placed concrete, can be sufficient to induce scaling.

The measures below can be beneficial for reducing concrete scaling. However, because of the other factors involved, including contractor workmanship, surface damage to concrete can develop even when the measures provided below are followed. Concrete mix design criteria should be coordinated with other project requirements including the criteria for soluble sulfate resistance presented in **Section 6.11**.

- Curing concrete in accordance with applicable codes and guidelines.
- Maintaining a water/cement ratio of 0.45 by weight for exterior concrete mixes.
- Including Type F fly ash in exterior concrete mixes as 20 percent of the cementitious material.
- Specifying a 28-day, compressive strength of 4,500 psi, or more, for exterior concrete.
- Including ‘fiber mesh’ in the concrete mix.
- Avoiding the use of de-icing salts through the first winter after construction and using Type V cement.

6.17 Construction in Cold or Wet Weather

During construction, the site should be graded such that surface water can drain readily away from excavations and structure areas. It is important to avoid ponding of water in or near excavations; water that accumulates in excavations should be promptly pumped out or otherwise removed and these areas should be allowed to dry out before resuming construction. Berms, ditches, and similar means should be used to decrease stormwater entering the work area and to efficiently convey it off site.

Earthwork activities undertaken during the cold weather season may be difficult and should be done by an experienced contractor. Fill should not be placed on top of frozen soils. The frozen soils should be removed prior to the placement of new engineered fill or other construction material. Frozen soil should not be used as structural fill or backfill. The frozen soil may be reused (provided it meets the selection criteria) once it has thawed completely. In addition, compaction of the soils may be more difficult due to the viscosity change in water at lower temperatures.

If construction proceeds during cold weather, foundations, slabs, or other concrete elements should not be placed on frozen subgrade soil. Frozen soil should either be removed from beneath concrete elements or thawed and recompacted. To limit the potential for soil freezing, the time passing between excavation and construction should be minimized. Blankets, straw, soil cover, or heating may be used to help discourage the soil from freezing.

6.18 Construction Observation and Testing

A qualified geotechnical consultant should perform appropriate observation and testing services during grading and construction operations. These services should include observation of removal of soft, loose, or otherwise unsuitable soils, evaluation of subgrade conditions where soil removals are performed, evaluation of the suitability of proposed borrow materials for use as fill, evaluation of the stability of open temporary excavations, evaluation of the results of any subgrade stabilization or dewatering activities, and performance of observation and testing services during placement and compaction of structural fill and backfill soils.

The geotechnical consultant should also perform observation and testing services during placement of concrete, mortar, grout, asphalt concrete, and steel reinforcement. If another geotechnical consultant is selected to perform observation and testing services for the project, the selected consultant should provide a letter to the owner, with a copy to AECOM, indicating that they fully understand the recommendations in this report and that they are in full agreement with them. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

6.19 Plan Review

The recommendations presented in this report are based on preliminary design information for the proposed project, as provided by HAL Engineers, and on the findings of our geotechnical evaluation. When finished, project plans and specifications should be reviewed by the geotechnical engineer prior to submitting the plans and specifications for bid. Additional field exploration and laboratory testing may be needed upon review of the project design plans.

6.20 Pre-Construction Meeting

A pre-construction meeting should be held prior to site excavation and foundation work. The owner or the owner's representative, the project architect or civil designer, the contractor, and the geotechnical consultant should be in attendance to discuss the plans and quality control program for the project.

7. Limitations

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation can be performed upon request.

The recommendations presented in this report are based on field exploration, laboratory testing, review of referenced maps and literature, and our understanding of the proposed construction. The soil data used in the preparation of this report were obtained from a limited number of subsurface explorations. It is possible that variation in the soil conditions will exist between or beyond the locations explored. Accordingly, if soil conditions are encountered during construction that are different from those outlined in this report, AECOM should be immediately notified so that we may review the situation that exists and make supplementary recommendations as needed. In addition, if the scope of the proposed construction, including the types of structures, anticipated loads and maximum cut and fill depths, changes from what is described in this report, we should be notified. This study was limited to assessment of geotechnical aspects of the project, and did not include evaluation of structural items, environmental concerns, or the presence of hazardous materials.

The recommendations presented in this report are also based on the assumption that an adequate number of tests and observations will be made during site construction to evaluate compliance with the recommendations. These tests and observations should be provided under the direction of a qualified geotechnical consultant. Such testing and observations should include, but not be limited to, the following:

- Review of site construction plans for conformance with geotechnical recommendations.
- Observation and testing during site preparation, grading, structure excavations, foundation installation, and placement of fill, aggregate base, concrete, mortar, grout, asphalt concrete, and steel reinforcement.
- Consultation, as needed during construction.

This document is intended to be used in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. AECOM should be contacted if additional information is needed or if questions regarding the content, interpretations presented, or completeness of this document arise.

Site conditions could change with time as a result of natural processes or the activities of man at the subject site or at nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which we have no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk. This report might not provide sufficient data to prepare an accurate bid by contractors. Bidders and their geotechnical consultant could perform an independent evaluation of the subsurface conditions in project areas; independent evaluations could include review of other geotechnical reports prepared for nearby areas, site reconnaissance, and additional subsurface exploration, laboratory testing, and geotechnical analyses.

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Appendix A Figures

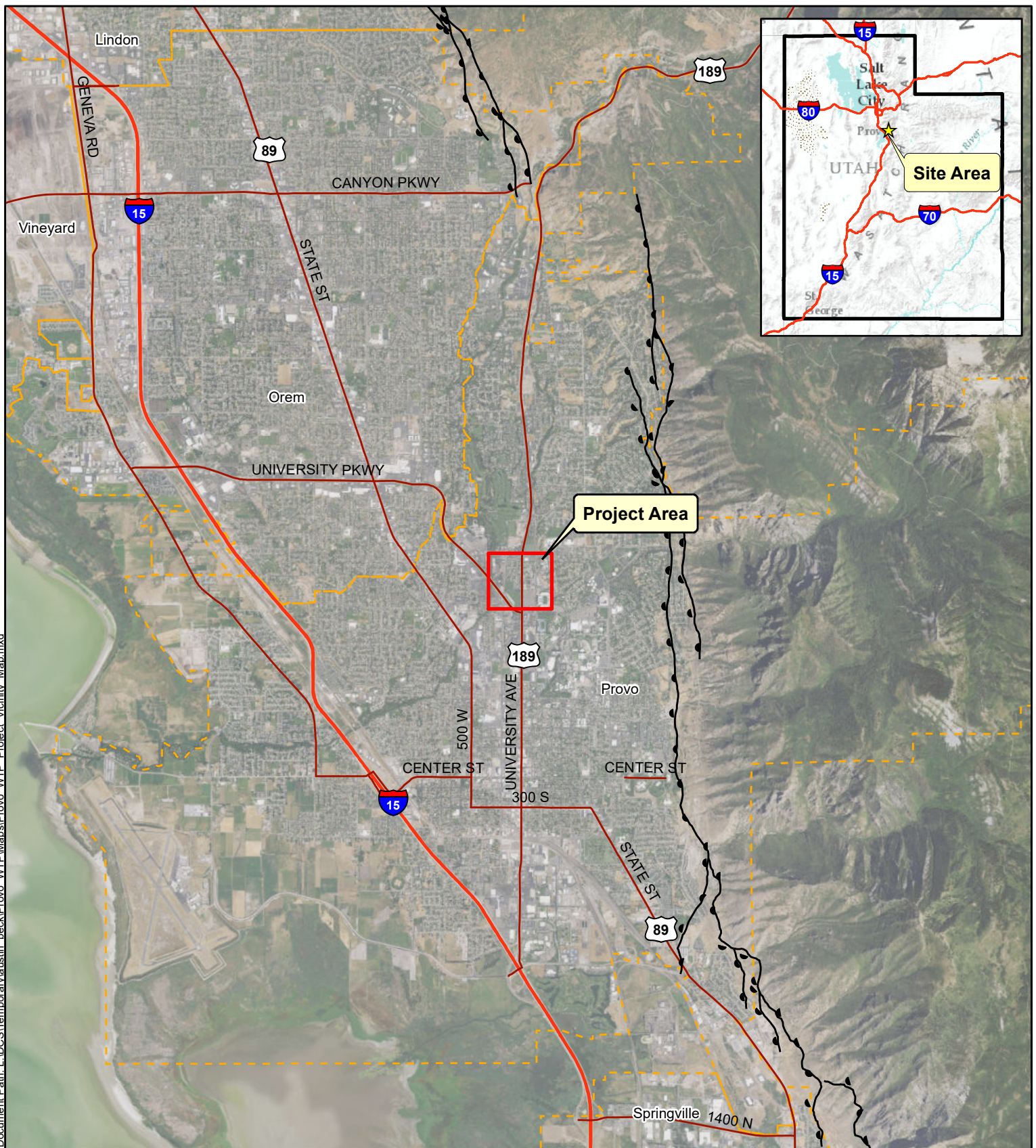
Project Vicinity

Geology

Subsurface Investigations (Pipeline Alignment)

Subsurface Investigations (Water Treatment Plant Site)

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- Fault (Dashed where inferred)
- Major Road
- Interstate
- Municipalities



0 0.75 1.5 3 Miles

Project Vicinity

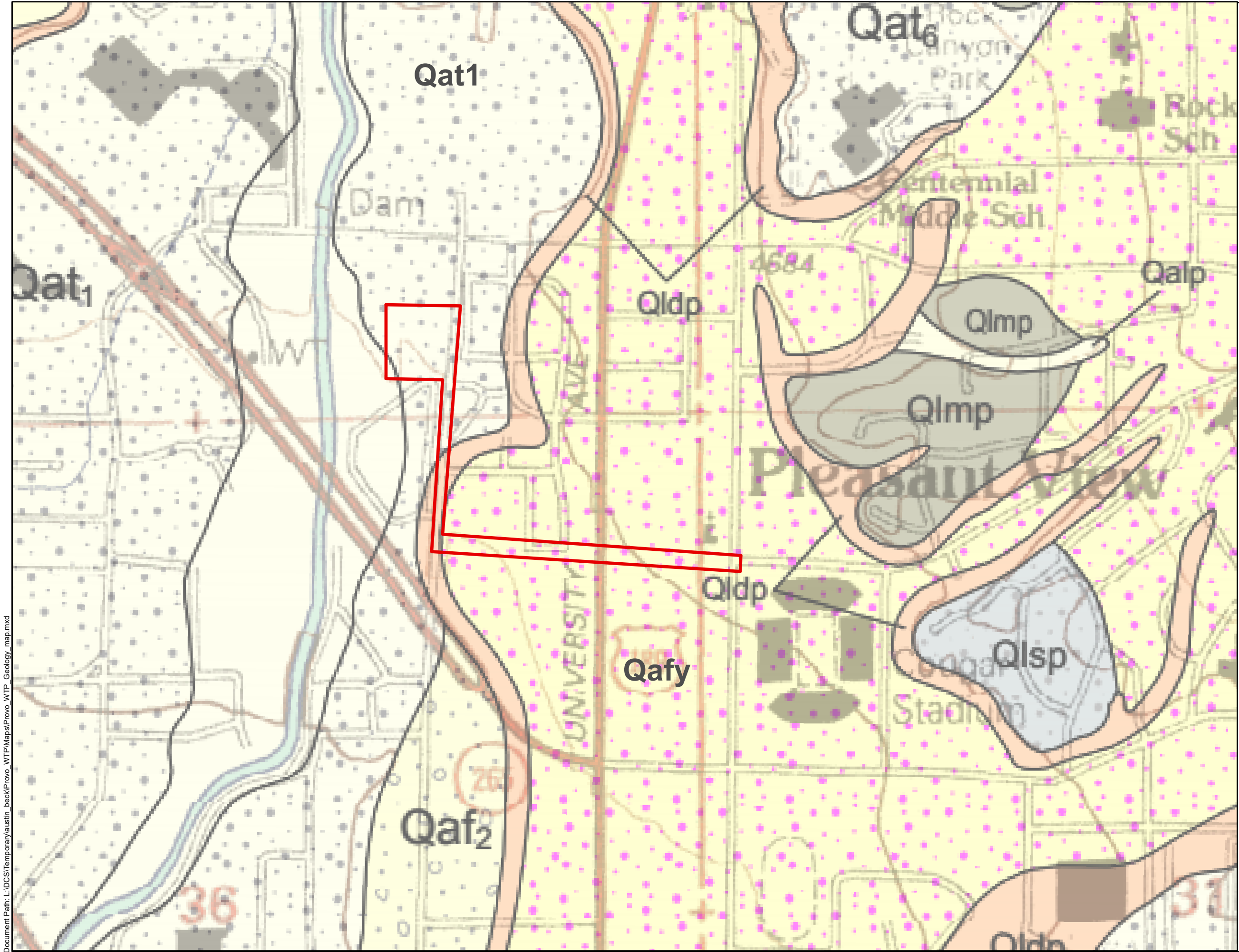
Provo City | HAL

Provo WTP
Provo, Utah

AECOM

Date: 9/2022

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Qat1

Stream-terrace deposits: (middle Holocene to upper Pleistocene) - Poorly to moderately sorted pebble and cobble gravel with a matrix of sand, silt, and minor clay; contains thin sand lenses; subangular to rounded clasts; thin to medium bedded. Lie 5 to 15 feet (1.5-5 m) above the Provo River and are incised by them

Qaf2

Level-2 alluvial-fan deposits (middle Holocene to upper Pleistocene) – Poorly sorted pebble and cobble gravel, locally bouldery, with a matrix of sand, silt, and minor clay; clasts angular to subrounded, with sparse well-rounded clasts derived from Lake Bonneville gravel; medium to very thick bedded.

Qldp

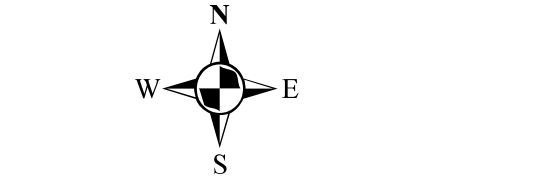
Deltaic deposits (upper Pleistocene) – Moderately to well-sorted, clast-supported, pebble and cobble gravel with a matrix of sand and silt; interbedded with thin pebbly sand beds; clasts subrounded to rounded; locally weakly cemented with calcium carbonate.

Qafy

Young alluvial-fan deposits, undivided (Holocene to upper Pleistocene)– Poorly to moderately sorted, pebble to cobblegravel with boulders near bedrock sources, with a matrix of sand, silt, and clay, grading to mixtures of sand, silt, and clay on gentler slopes.

— Contact
Long-dashed where approximately located;
short dashed where inferred

Project Area





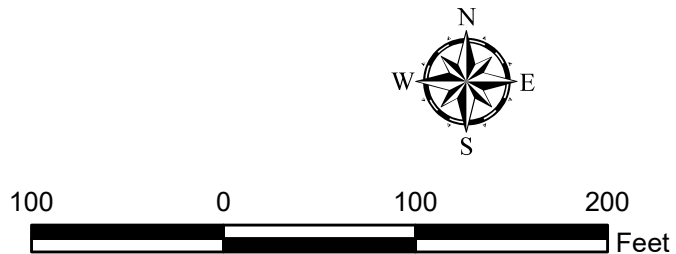
Geology	
Provo City HAL	
Provo WTP Provo, Utah	
AECOM	Date: 9/2022

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Source Aerial Photograph: High Resolution Ortho-Imagery, Automated Geographic Reference Center.

-  Boring
-  36" Transmission Pipeline

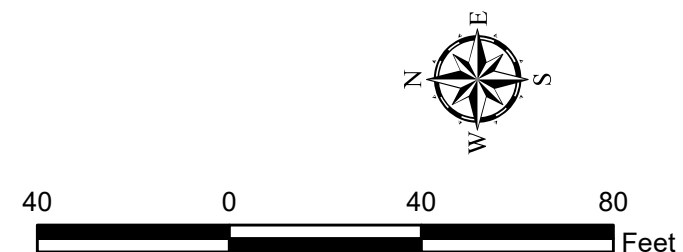


Subsurface Investigations	
Provo City HAL	
Provo WTP Provo, Utah	
AECOM	Date: 9/2022

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- ▼ Cone Penetration Test
- ⊕ Boring
- ▭ Proposed Facility
- 36" Transmission Pipeline



Subsurface Investigations	
Provo City HAL	
Provo WTP Provo, Utah	
AECOM	Date: 9/2022

Appendix B Logs of Soil Borings

Key to Boring Logs

CONSISTENCY OR CONDITION OF SOILS

Fine-Grained Soils (Silt and Clay): Major portion passing #200 sieve

Relative Consistency	N ₆₀ SPT, Blows/foot	Shear Strength, tsf	Unconfined Compressive Strength, tsf	Field Behavior
Very Soft	< 2	< 0.13	< 0.25	Easily penetrated several inches by fist
Soft	2 - 4	0.13 - 0.25	0.25 - 0.5	Easily penetrated several inches by thumb
Medium Stiff	5 - 8	0.25 - 0.5	0.5 - 1	Penetrated several inches by thumb with moderate effort
Stiff	9 - 15	0.5 - 1	1 - 2	Readily indented by thumb but penetrated only with great effort
Very Stiff	16 - 30	1 - 2	2 - 4	Readily indented with thumbnail
Hard	> 30	> 2	> 4	Indented with difficulty by thumbnail

Coarse-Grained Soils (Sand and Gravel): Major portion retained on #200 sieve

Apparent Density	(N ₁) ₆₀ SPT, Blows/foot	Relative Density, %	Field Test with 1/2-in Steel Rod
Very Loose	< 5	0 - 20	Very easily penetrated when pushed by hand
Loose	5 - 10	20 - 40	Easily penetrated when pushed by hand
Medium Dense	11 - 30	40 - 70	Easily penetrated when driven with 5-lb hammer
Dense	31 - 50	70 - 85	Penetrated 1 ft with difficulty when driven with 5-lb hammer
Very Dense	> 50	85 - 100	Penetrated less than 3 in. when driven with 5-lb hammer

Particle Size Descriptions for Sand and Gravel

Description	Gravel Size	Sand Size	Size Requirement
Coarse	3-in. to 3/4-in.	#4 to #10 sieve	<30% medium to fine sand or <12% fine gravel
Coarse to medium	--	--	<12% fine sand
Medium	--	#10 to #40 sieve	<12% coarse sand and >30% medium sand
Medium to fine	--	--	<30% medium sand or <12% coarse gravel
Fine	3/4-in. to #4 sieve	#40 to #200 sieve	<30% medium sand or <12% coarse gravel
Coarse to fine	--	--	>12% of each size

Moisture Conditions

Dry	No indication of moisture, dusty
Slightly Moist	Appears dry, but some moisture present
Moist	Damp but no visible water
Wet	Visible free water

Structure and Layering of Soils

Stratum	>12 inches thick
Layer	1/2 inch to < 12 inches
Seam	1/16 inch to 1/2 inch
Parting	< 1/16 inch
Frequent	More than one per foot
Varved	Frequent alternating layers, seams, or partings of sand, silt, or clay
Pocket	Small erratic deposit
Lens	Non-continuous lenticular deposit

Plasticity of Fine-Grained Soils

Nonplastic	1/8-in thread cannot be rolled at any water content
Low	Thread can barely be rolled and lump cannot be formed when drier than the plastic limit
Medium	Thread is easy to roll with little time required to reach plastic limit. Thread cannot be rerolled after reaching the plastic limit.
High	Considerable time rolling and kneading to reach plastic limit. Thread can be rerolled several times after reaching plastic limit.

Unified Soil Classification System

Major Divisions			Symbols
			Graphic Letter
Coarse-Grained Soils More than 50% of Material is Retained on No. 200 Sieve	Gravels More than 50% of Coarse Fraction is Retained on No. 4 Sieve	Clean Gravels (little or no fines)	GW
		Gravels with Fines (appreciable amount of fines)	GP
	Sands More than 50% of Coarse Fraction Passes No. 4 Sieve	Clean Sand (little or no fines)	GM
		Sands with Fines (appreciable amount of fines)	GC
Fine-Grained Soils More than 50% of Material Passes No. 200 Sieve	Sands More than 50% of Coarse Fraction Passes No. 4 Sieve	Clean Sand (little or no fines)	SW
		Sands with Fines (appreciable amount of fines)	SP
	Silts and Clays	Liquid Limit Less than 50	SM
		Liquid Limit 50, or more	SC
Highly Organic Soils	Silts and Clays	Liquid Limit Less than 50	ML
		Liquid Limit 50, or more	CL
	Silts and Clays	Liquid Limit Less than 50	OL
		Liquid Limit 50, or more	MH
Highly Organic Soils	Silts and Clays	Liquid Limit Less than 50	CH
		Liquid Limit 50, or more	OH
	Silts and Clays	Liquid Limit Less than 50	PT
		Liquid Limit 50, or more	PT

Note: Dual Symbols are used to indicate borderline soil classifications

TYPICAL SAMPLER GRAPHIC SYMBOLS

	3.25" OD Dames & Moore Sampler
	3" OD Shelby Tube
	Sonic Core Sample
	2" OD Split Spoon (SPT)
	Piston Sample
	Grab Sample

TYPICAL WATER LEVEL SYMBOLS

	Measured Water Level after minimum of 16 hours
	Estimated or observed water level at time of drilling

KEY TERMINOLOGY

CBR	- California bearing ratio
CONS	- One-Dimensional Consolidation Test
CORR	- Corrosion tests
DS	- Direct shear test
F	- Percent fines by weight passing #200 sieve
G	- Percent gravel by weight
γ_d	- Dry unit weight
γ_{d-max}	- Maximum dry unit weight as per ASTM D698 or D1557
LL	- Liquid Limit
N	- Number of blows to drive sampler through the second and third 6-inch soil intervals using a 140-lb hammer dropped 30 inches
N₆₀	- SPT N value corrected for field procedures
(N₁)₆₀	- SPT N ₆₀ value corrected for effective overburden pressure
NP	- Nonplastic
OD	- Outer diameter
PI	- Plasticity index
PP	- Pocket penetrometer
S	- Percent sand by weight
SG	- Specific gravity
SPT	- Standard Penetration Test
SS	- Direct simple shear test
TV	- Torvane
TXCD	- Consolidated drained triaxial test
TXCU	- Consolidated undrained triaxial test
TXCY	- Cyclic triaxial test
TXUU	- Unconsolidated undrained triaxial test
UC	- Unconfined compression test
W	- Moisture content
W_{opt}	- Optimum moisture content associated with ASTM D698 or D1557

Descriptions and layers are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

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Project: Provo Water Treatment Plant	Log of Boring DH22-HDD-01
Project Location: Provo, UT	Sheet 1 of 2
Project Number: 60670884	

Date(s) Drilled: 3/21/2022	Drill Rig Type: Boart Longyear LS600C (Track)	Logged By: BB	Checked By: SM
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 82.4%	Total Depth of Borehole: 43 feet	
Drilling Method: Sonic (Dry) Bit Size/Type: 4-3/4" Button Bit; 6" OD Casing	Borehole Backfill: Bentonite chips to 1' bgs; sand/gravel base; coldpatch asphalt	Surface Elevation: 4642.2 feet	
Sampling Method(s): 18" SPT, 4-3/4" Sonic Core (Bag)	Estimated Groundwater Level at Time of Drilling: Not Encountered	Groundwater Level and Date Measured: Not Measured	
Location: N 7263070.4 ft, E 1596073.8 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES						Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %			
	0								3 inches of ASPHALT concrete pavement	Began drilling at approx. 14:30 Sonic Core Run 01: 0.0-6.5'; Recovery = 100%
		☞	B-01						Fill: Silty SAND with gravel (SM), medium dense, moist, dark brown	
4640		☞	B-02						Native: Sandy lean CLAY (CL), stiff to very stiff, moist, gray brown	PP=2.0-2.5 tsf
	5									
		☞	B-03						Silty CLAY with sand (CL-ML), medium stiff, slightly moist to moist, gray brown; sand is fine sand	Sonic Core Run 02: 6.5-11.5'; Recovery = 100% W=14%; LL=23; PI=5; G=0%; S=17.4%; F=83%
4635		☛	SPT-04	3 2 3 N=5	6	7	100			
		☞	B-05							
	10								...5-inch-thick layer of sandy lean clay	
		☛	SPT-06	2 3 3 N=6	7	8	67			Sonic Core Run 03: 11.5-21.5'; Recovery = 100%
4630		☞	B-07						Silty SAND (SM), loose to medium dense, moist, gray brown	W=17.4%; LL=25; PI=6; G=0%; S=12.5%; F=88%; CORR PP=1.75-2.5 tsf
									Silty CLAY (CL-ML), stiff to very stiff, moist, dark brown	
	15	☞	B-08							
4625										
		☞	B-09						...9-inch-thick layer of silty fine sand	
	20									Sonic Core Run 04: 21.5-31.5'; Recovery = 100%
4620		☛	SPT-10	3 2 4 N=6	8	7	94		Clayey SAND (SC), loose to medium dense, moist, dark brown; sand is fine sand	
		☞	B-11						Silty CLAY (CL-ML), medium stiff to very stiff, moist to wet, dark brown	W=22.2%; LL=24; PI=4; G=0.1%; S=10.2%; F=90% PP=1.5-2.5 tsf
	25									

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Project: Provo Water Treatment Plant	Log of Boring DH22-HDD-01
Project Location: Provo, UT	Sheet 2 of 2
Project Number: 60670884	

Elevation feet	Depth, feet	SAMPLES						Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %			
	25								...2-inch-thick layer of silty sand	
4615			B-12						SILT with sand (ML), soft to stiff, wet, dark brown; sand is fine sand	From 27-29 ft; PP=0.5-1.5 tsf; TV=0.15 tsf
	30		B-13						Silty GRAVEL with sand (GM), loose to medium dense, slightly moist to moist, brown gray to gray brown; gravel up to 3 inches in diameter, subrounded to angular	
4610			SPT-14	9 5 3 N=8	11	9	3			Sonic Core Run 05: 31.5-41.5'; Recovery = 100%
			B-15						SILT with sand and gravel (ML), soft to medium stiff, moist, dark brown; trace gravel	
	35		B-16						Silty SAND with gravel (SM), medium dense, moist, dark gray brown	
4605			B-17						Poorly graded GRAVEL with sand (GP), medium dense, slightly moist to moist, gray brown; gravel and cobbles up to 4 inches in diameter, subrounded to subangular	W=2%; NP; G=73.3%; S=22.2%; F=5%
	40									
4600			SPT-18	1 7 7 N=14	19	13	28		Silty SAND with gravel (SM), medium dense, slightly moist to moist, gray brown; gravel up to 1 inch in diameter	
										Bottom of Exploration at 43 feet 16:30 3/21/2022
4595										
4590										

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-P-01

Sheet 1 of 1

Date(s) Drilled: 3/21/2022	Drill Rig Type: Boart Longyear LS600C (Track)	Logged By: BB	Checked By: SM
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 82.4%	Total Depth of Borehole: 18 feet	
Drilling Method: Sonic (Dry) Bit Size/Type: 4-3/4" Button Bit; 6" OD Casing	Borehole Backfill: Bentonite chips to 1' bgs; sand/gravel base; coldpatch asphalt	Surface Elevation: 4649.2 feet	
Sampling Method(s): 18" SPT, 4-3/4" Sonic Core (Bag)	Estimated Groundwater Level at Time of Drilling: Not Encountered	Groundwater Level and Date Measured: Not Measured	
Location: N 7263020.0 ft, E 1596784.8 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
0								3 inches of ASPHALT concrete pavement	Began drilling at approx. 11:30 Sonic Core Run 01: 0.0-6.5'; Recovery = 100%
								Fill: Silty SAND with gravel (SM), medium dense, moist, gray brown ...from 1.4-2.0', 8-inch-thick layer of silty gravel with sand	
								Native: Sandy silty CLAY (CL-ML), medium stiff, moist, dark brown; trace organics, gravel up to 4 inches in diameter, subrounded	W=15.9%; LL=24; PI=7; G=10.5%; S=26.1%; F=63%
4645		BK-01							
	5							...loose to medium dense, trace gravel, no organics	30-minute repair of hydraulic line connection for auto hammer before first SPT
		SPT-02		4 3 3 N=6	7	8	83		Sonic Core Run 02: 6.5-11.5'; Recovery = 100%
		B-03						Silty CLAY with sand (CL-ML), medium stiff to very stiff, moist (appeared dry of or near plastic limit), gray brown	W=37.5%; LL=23; PI=5; G=0%; S=21.5%; F=79%; CORR
4640									PP=1.5-2.25 tsf; TV=0.45 tsf
	10							...with gravel, very stiff to stiff, dark brown	Sonic Core Run 03: 11.5-16.5'; Recovery = 100%
		SPT-04		4 4 10 N=14	16	18	72		
		B-05						Silty GRAVEL with sand (GM), medium dense, slightly moist to moist, gray brown; gravel up to 3 inches in diameter, subangular to subrounded	
4635									
	15							Silty SAND (SM), medium dense, slightly moist to moist, gray brown	6-inches of caved-in soil in top of split spoon; 6 inches of natural sample
		B-06							
		SPT-07		5 8 7 N=15	20	19	33		
4630									Bottom of Exploration at 18 feet 13:30 3/21/2022
4625									

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Project: Provo Water Treatment Plant	Log of Boring DH22-P-02
Project Location: Provo, UT	Sheet 1 of 1
Project Number: 60670884	

Date(s) Drilled: 3/22/2022	Drill Rig Type: Boart Longyear LS600C (Track)	Logged By: BB	Checked By: SM
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 82.4%	Total Depth of Borehole: 18 feet	
Drilling Method: Sonic (Dry) Bit Size/Type: 4-3/4" Button Bit; 6" OD Casing	Borehole Backfill: Bentonite chips to 1' bgs; sand/gravel base; coldpatch asphalt	Surface Elevation: 4633.0 feet	
Sampling Method(s): 18" SPT, 4-3/4" Sonic Core (Bag)	Estimated Groundwater Level at Time of Drilling: Not Encountered	Groundwater Level and Date Measured: Not Measured	
Location: N 7263092.2 ft, E 1595438.9 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
0								3 inches of ASPHALT concrete pavement	Began drilling at approx. 08:15
		B-01						Fill: Silty SAND with gravel (SM), medium dense, slightly moist to moist, brown gray; gravel up to 1 inch in diameter	Sonic Core Run 01: 0.0-6.5'; Recovery = 100%
4630								Native: Lean CLAY (CL), medium stiff to very stiff, moist, dark gray brown	W=19.7%; LL=29; PI=10; G=0%; S=7.7%; F=92%; CORR
	5	BK-02							At 4'; TV=0.45 tsf; from 4-6'; PP=2.0-3.0 tsf
		SPT-03		1 2 3 N=5	6	7	94	...medium stiff to stiff	Sonic Core Run 02: 6.5-11.5'; Recovery = 100%
4625									At 7.5' in split spoon; PP=1.75 tsf At 8' in sonic core sample; PP=1.75 tsf
	10	B-04						...3-inch-thick layer of silty sand	
								Silty CLAY (CL-ML), medium stiff to stiff, moist, dark gray brown	W=22.2%; LL=27; PI=7; G=0%; S=8.6%; F=91%
		SPT-05		2 3 4 N=7	8	9	94	...medium stiff to very stiff; sandier in split spoon only	At 10.5; PP=1.5-2.0 tsf
4620									Sonic Core Run 03: 11.5-16.5'; Recovery = 100%
								Lean CLAY (CL), medium stiff to stiff, moist, dark gray brown	From 11.5-12.5'; PP=1.25-2.75 tsf At 12.5'; TV=0.4 tsf; from 12.5-14.5'; PP=1.0-1.5 tsf
	15	B-06							At 14'; TV=0.35 tsf W=21.8%; LL=30; PI=11; G=0%; S=7.4%; F=93%
								...4-inch-thick layer of silty sand	
		SPT-07		2 2 3 N=5	7	6	100		From 16.5-18.0'; PP=1.5-2.0 tsf
4615									
									Bottom of Exploration at 18 feet 09:30 3/22/2022
4610									

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Project: Provo Water Treatment Plant	Log of Boring DH22-P-03
Project Location: Provo, UT	Sheet 1 of 1
Project Number: 60670884	

Date(s) Drilled: 3/22/2022	Drill Rig Type: Boart Longyear LS600C (Track)	Logged By: BB	Checked By: SM
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 82.4%	Total Depth of Borehole: 16.1 feet	
Drilling Method: Sonic (Dry) Bit Size/Type: 4-3/4" Button Bit; 6" OD Casing	Borehole Backfill: Bentonite chips to 1' bgs; sand/gravel base; coldpatch asphalt	Surface Elevation: 4622.6 feet	
Sampling Method(s): 18" SPT, 4-3/4" Sonic Core (Bag)	Estimated Groundwater Level at Time of Drilling: Not Encountered	Groundwater Level and Date Measured: Not Measured	
Location: N 7263710.4 ft, E 1595266.6 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
0								5 inches of ASPHALT concrete pavement	Began drilling at approx. 12:00
								Fill: Silty SAND with gravel (SM), medium dense, slightly moist to moist, very dark brown	Sonic Core Run 01: 0.0-6.0'; Recovery = 100%
								Sandy SILT with gravel (ML), medium stiff, moist, very dark brown; gravel up to 3 inches in diameter	
4620								Native: Silty SAND with gravel (SM), medium dense, moist, very dark gray to black; sand is fine to coarse, with gravel up to 2 inches in diameter, with wood and organic matter	W=36.9%; LL=32; PI=7; G=32.5%; S=36.5%; F=31%; CORR; Organic Content=28.5% PP=0.25 tsf
	5	B-01							
				7 7 6 N=13	14	19	67		
4615		SPT-02						...sand is fine to medium, no longer contains wood and organic matter	Sonic Core Run 02: 6.0-11.0'; Recovery = 100%
	10	B-03						Silty GRAVEL with sand (GM), very dense to dense, slightly moist in upper 8 inches, moist below, dark brown; gravel and cobbles up to 4 inches in diameter	
		SPT-04	50/3"	--	--	--	67	...contains cobbles up to 7 inches in diameter or larger	SPT-04 sample discarded Sonic Core Run 03: 11.0-16.0'; Cobble stuck in barrel; lost core ~11.8-13.0'; Recovery = 76%
4610									
								Poorly graded GRAVEL with silt and sand (GP-GM), very dense to dense, moist, dark brown; gravel and cobbles up to 4 inches in diameter	W=4%; G=75.4%; S=16.8%; F=8%; CORR
	15	B-05							
		SPT-06	50/1"	--	--	--	0		No recovery in split spoon at 16.0' Bottom of Exploration at 16.1 feet 13:00 3/22/2022
4605									
4600									

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-WTP-01

Sheet 1 of 5

Date(s) Drilled: 3/22/2022 - 3/23/2022	Drill Rig Type: Boart Longyear LS600C (Track)	Logged By: BB	Checked By: SM
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 82.4%	Total Depth of Borehole: 118 feet	
Drilling Method: Sonic (Dry, Wash) Bit Size/Type: 4-3/4" Button Bit; 6" OD Casing	Borehole Backfill: Grout 118-10'; bentonite chips 10-1'; sand/gravel base; coldpatch asphalt	Surface Elevation: 4626.4 feet	
Sampling Method(s): 18" SPT, 3" OD Shelby Tube, 4-3/4" Sonic Core (Bag)	Estimated Groundwater Level at Time of Drilling: 15.3 feet	Groundwater Level and Date Measured: 13.8 feet 3/23/2022 08:00	
Location: N 7264241.4 ft, E 1595194.1 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
0								4 inches of ASPHALT concrete pavement	Began drilling at 14:05 3/22/2022
4625								Fill: Silty SAND with gravel (SM), medium dense, moist, very dark brown	Sonic Core Run 01: 0.0-6.5'; Recovery = 100%
		B-01						Native: Sandy lean CLAY with gravel (CL), medium stiff to stiff, moist, very dark brown; trace organics	At 2'; PP=0.5-2.0 tsf
								Silty GRAVEL with sand (GM), very dense to dense, moist, very dark brown; gravel up to 3 inches in diameter	CORR
5		B-02							
4620									
		B-04		11	49	62	61		
		SPT-03		25					
				19				...contains cobbles 5 inches in diameter or larger	Sonic Core Run 02: 6.5-11.5'; Cobble stuck in barrel; lost core ~7.5-11.0'; Recovery = 30% At 6.5'; rock in shoe of split spoon
				N=44					
10									
4615									
		SPT-04B		10	--	--	44	...contains cobbles 6 inches in diameter or larger	At 11.5'; rocks in split spoon; sample discarded
				50/3"					At 11.5'; driller noted many rocks (gravel and cobbles); began using 6-inch casing with water
									Sonic Core Run 03: 11.5-21.5'; Cobble stuck in barrel; lost core ~11.7-20.5'; Recovery in first attempt = 12%; reamed hole 16.5'-21.5' on 3/23/2022; Recovery = 92%
15									Water observed at 15'-3" bgs 16:45 3/22/2022
4610									Water observed at 13'-9" bgs 08:00 3/23/2022
		B-08							
20								...contains cobbles 7 inches long or larger (based on ream run on 3/23/2022)	B-08 from second attempt to recover (ream) 16.5'-21.5'
4605		B-05							
		SPT-06		4	11	10	61	Sandy SILT with gravel (ML), stiff, wet, very dark gray; sand is fine sand; not plastic to low plasticity	SPT-06: W=21.1%; NP; G=16.8%; S=32.6%; F=51%
				4					Sonic Core Run 04: 21.5-26.5'; Driller noted highly saturated conditions; indicated that sample fell out of barrel; also piece of cobble in top of barrel; Recovery in first attempt = 17%; attempted Run 04 again on 3/23/2022; Recovery =
		B-07							
		B-09							
25									

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-WTP-01

Sheet 2 of 5

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %		
4600	25	SPT-10	B-11	14 16 5 N=21	28	26	100	...with gravel (based on second attempt to recover on 3/23/2022) Sandy SILT (ML), very stiff to stiff, wet, dark brown gray; not plastic to low plasticity, sand is fine sand	23% End of day 17:00 3/22/2022 after first attempt to recover Run 04 and making 2 new holy rods (previous rods broke) B-09 from second attempt to recover 21.5-26.5' Beginning of day 08:10 3/23/2022; driller stopped using water; reamed casing to 21.5' (sampled from 16.5-21.5'); then re-attempted run from 21.5-26.5' SPT-10: W=20.2%; NP; G=14.3%; S=32.5%; F=53% Sonic Core Run 05: 26.5-36.5'; Recovery = 100% At 30.5'; PP=0.5 tsf; TV=0.25 tsf
4595	30	B-12						Lean CLAY with sand (CL), medium stiff, moist, very dark gray; low to medium plasticity ...trace organics from 31-32'	B-12: W=26.9%; LL=30; PI=10 At 33.0'; PP=0.5-0.6 tsf; TV=0.375 tsf At 34.5'; PP=0.7 tsf; TV=0.35 tsf
4590	35	SH-13					67	Sandy SILT (ML), medium stiff to stiff, wet, very dark gray; ranges from nonplastic to low plasticity, sand is fine sand	Pushed Shelby tube at 09:40; retrieved at 10:10; bottom of tube bent; 3-4" rock in core run Test on Clay: LL=33; PI=12; CONS Driller began using water again as needed at 36.5' (Run 06) Sonic Core Run 06: 36.5-46.5'; Recovery = 100%
4585	40	B-14						...contains organics from 41.5 - 43.5'	At 40.0'; PP=1.5-2.0 tsf; TV=0.4 tsf
4580	45	SPT-15	B-16	3 7 8 N=15	21	17	100	Lean CLAY (CL), very stiff to stiff, moist, very dark gray; trace organics (few seams per foot)	At 44.0' in nonplastic zone; PP=~1.0 tsf; TV=~0.15 tsf At 46'; PP=1.0-1.5 tsf; TV=0.4 tsf Sonic Core Run 07: 46.5-56.5'; Recovery = 100% SPT-15 sample is of lower material At 47.5' in split spoon; PP=1.5 tsf At 48' in core; PP=1.5-2.25 tsf; TV=0.7-0.9 tsf
4575	50							Sandy SILT (ML), stiff, moist to wet, very dark gray; trace organics	At 51'; PP=1.5 tsf
55	55								

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-WTP-01

Sheet 3 of 5

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %		
55		B-17							At 55.5'; PP=1.5 tsf
4570		SH-18					100	Lean CLAY (CL), stiff, moist to wet, very dark gray; frequent seams with organics, some partings to seams of fine sand	Test on Silt: W=23.2%; LL=26; PI=4; G=0%; S=12.3%; F=88%; Test on Clay: CONS Pushed Shelby tube at 11:30; retrieved at 12:00; slight bend in bottom of tube; unable to place lower o-ring packer Sonic Core Run 08: 56.5-66.5'; Recovery = 100%
60		B-19							At 61.5'; PP=2.0 tsf; TV=0.825 tsf
4565									
65		B-20						Sandy SILT (ML), stiff, wet, very dark gray; some seams with organics	At 65.5'; PP=1.4-1.7 tsf
4560		SH-21					100	Lean CLAY (CL), stiff, moist to wet, very dark gray	10 minute wait time on SH-21 Test on Clay: W=35.6%; LL=48; PI=24; G=0%; S=3.5%; F=97%; CONS Sonic Core Run 09: 66.5-76.5'; Recovery = 100%
70		B-22						...transitioning to silty sand	At 69.0'; PP=1.5 tsf
4555		B-23						Silty SAND (SM), medium dense, moist, very dark gray; sand is fine sand	
75		B-24						Poorly graded SAND with silt (SP-SM), dense, slightly moist to moist, dark gray to very dark gray; mostly fine sand	W=4%; G=0.1%; S=94.2%; F=6%
4550		SPT-25		10 21 31 N=52	73	49	83	Silty SAND (SM), dense, moist to wet, very dark gray; occasional layers of silt or clay up to 7 inches thick	SPT-25 sample discarded (interlayered) Sonic Core Run 10: 76.5-86.5'; Recovery = 100%
80		B-26							
4545									
85									

[illegible]

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Project: Provo Water Treatment Plant	Log of Boring DH22-WTP-01 Sheet 5 of 5
Project Location: Provo, UT	
Project Number: 60670884	

Elevation feet	Depth, feet	SAMPLES						Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %			
115										
4510		SPT-35	22 21 37 N=58	81	45	78			Silty SAND (SM), dense, moist to wet, very dark gray; trace organics, sand is fine sand	
4505										Bottom of Exploration at 118' 15:15 3/23/2022
4500										
4495										
4490										
4485										

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Project: Provo Water Treatment Plant	Log of Boring DH22-WTP-02
Project Location: Provo, UT	Sheet 1 of 3
Project Number: 60670884	

Date(s) Drilled: 8/1/2022-8/2/2022	Drill Rig Type: FRASTE MD-XL (Track; SN: 574704)	Logged By: BB/SR	Checked By: ER
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 83%	Total Depth of Borehole: 80 feet	
Drilling Method: ODEX, Mud Rotary Bit Size/Type: ODEX (4-1/2"); Tricone (3-7/8")	Borehole Backfill: Soil cement; coldpatch asphalt	Surface Elevation: 4628.0 feet	
Sampling Method(s): 24" SPT, Mod Cal, 3" OD Shelby Tube	Estimated Groundwater Level at Time of Drilling: 15.2 feet	Groundwater Level and Date Measured: Not Measured	
Location: N 7264082.9 ft, E 1595276.1 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
0								2 inches of ASPHALT concrete pavement	Began ODEX drilling at 10:40
		SPT-01		14 2 2 2 N=3	3	6	46	Fill: Poorly graded SAND with silt and gravel (SP-SM), medium dense, slightly moist, very dark brown	
4625		SPT-02		1 2 2 2 N=4	4	6	50	Native: Lean CLAY with sand (CL), soft to medium stiff, moist, very dark brown; few organics; low plasticity ...no organics; trace fine sand particles	LL=26; PI=8; G=0%; S=29.0%; F=71.0% At 3'; PP=0.5-0.75 tsf
5		SPT-03		1 1 2 2 N=3	3	5	54	...trace gravel	At 5.5'; PP=0.25-0.6 tsf
4620								Poorly graded GRAVEL (GP), dense, slightly moist, brown gray; some cobbles	Rough drilling starting at 6.5'
10		SPT-04		27 41 50/2"	--	--	50	...very dense; trace silt in upper 4 inches of sample; some sand particles (but may be crushed rock)	
4615								...possible boulder at 11.5'	VERY slow; rough drilling between 11.5'-12.5' (~1hr to drill)
15		SPT-05		19 14 20 26 N=34	45	47	33	...dense, wet, 4-inch-thick layer with silt	Groundwater observed during drilling at ~15.2' bgs
4610									
20		SPT-06 MC-01		4 6 8 8 N=14	19	18	0 100	SILT with sand (ML), very stiff, wet, orange brown in upper 2 inches and very dark gray below; 2-inch-thick layer of lean clay at 21.5'; fine sand particles	Softer soil drilling below ~19' Because of need to case to 24' & no recovery on SPT at 20'; drove mod cal 20-22'; disturbed blowcounts 1-4-9-11 (100% recovery on MC-01) W=24.7%; NP At 21'; PP=1.0-1.5 tsf
4605		SPT-07		3 3 6 8 N=9	12	12	96	...stiff, very dark gray; trace organics	At 21.5'; TV=0.15 tsf NP; G=0%; S=16%; F=84.0% At 22.5-23.5'; PP=0.75-1.5 tsf
25				8 8				...very stiff; higher sand content; no organics except for 2-inch-thick layer near 25.5'	At 24'; set casing and began mud rotary drilling; NP; G=0%; S=33%;

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-WTP-02

Sheet 2 of 3

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N _{1/60}) blowcount	Recovery, %			
4600	25	SPT-08	8 11 N=16	21	20	79		Silty SAND (SM), medium dense, wet, very dark gray; nonplastic except for 4-inch-thick layer at 26' (discarded)	F=67.0% At 25'; PP=1.2-1.6 tsf NP; G=0%; S=63.5%; F=36.5%
		SPT-09	4 5 11 N=9	12	11	83			
4595	30							SILT (ML), medium stiff, wet, very dark gray; low plasticity fines	G=0%; S=1%; F=99.0%
		SPT-10A SPT-10B	3 3 3 5 N=6	8	8	100			
4590	35	S SH-01				100		Lean CLAY (CL), medium stiff, wet, very dark gray; trace fine sand	W=27.0%; LL=31; PI=13 At 33-34'; PP=0.75-1.2 tsf
		S SH-02				100			
4585	40							...stiff, moist, occasional partings and seams of sandy silt; appears just wet of plastic limit	Pushed Shelby tube at 16:50; retrieved at 17:15; tube completely full; driller noted might have been over-pushed; LL=29; PI=13; G=0%; S=7.2%; F=92.8%; CONS At 36.9'; PP=1.2-2.0 tsf; TV=0.53 tsf At 37'; EOD 17:45 8/1/2022; W=28.1%; LL=34; PI=14; γ _s =97.8 pcf; CONS At 38.9': PP=1.5-2.5 tsf; TV=0.3 tsf
		SPT-11	8 8 9 11 N=17	24	20	92			
4580	45	SPT-12	8 10 13 10 N=23	32	26	88		Lean CLAY, very stiff, wet, very dark gray; some seams of sandy silt	At 41-42': PP=2.5-3.5 tsf; TV=0.4 tsf NP; G=0%; S=35.1%; F=64.9% At 43-44': PP=1.5-2.0 tsf; TV=0.4 tsf
		SPT-13	13 10 8 11 N=18	25	20	88			
4575	50	SPT-14	5 11 18 31 N=29	41	32	83		SILT (ML), hard to very stiff, wet, dark gray; some sand seams	W=24.9%; LL=26; PI=9 At 45-46': PP=1.0-2.0 tsf; TV=0.2 tsf
		SPT-15	15 15 16 17 N=31	44	34	83			
4570	55	SPT-16	2 4 5 4 N=9	13	10	100		Lean CLAY (CL), stiff, wet, very dark gray	LL=27; PI=9 At 51': PP=1.0-1.5 tsf; TV=0.4 tsf

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Project: Provo Water Treatment Plant	Log of Boring DH22-WTP-02 Sheet 3 of 3
Project Location: Provo, UT	
Project Number: 60670884	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %		
55									
4570		G	SH-03				83		Pushed Shelby tube at 10:28; retrieved at 10:48 LL=34; PI=15; CONS
60									At 59.9': PP=2.0-2.5 tsf; TV=0.25 tsf
4565									
65		▲	SPT-17	19 20 26 27 N=46	65	46	88	...hard to stiff; medium plasticity fines	At 65': PP=1.25-2.0 tsf; TV=0.2 tsf
4560									
70								SILT (ML), stiff, wet, dark gray	
		G	SH-04				83		Pushed Shelby tube at 11:34; retrieved at 12:04 Test on silt: NP; G=0%; S=10.7%; F=89.3%; Test on clay: CONS
4555								Lean CLAY (CL), very stiff, wet, dark gray	At 72.9': PP=2.5-2.75 tsf; TV=0.6 tsf
75									
4550		▲	SPT-18	21 35 26 32 N=61	86	57	92	Silty SAND (SM), very dense, wet, dark gray; fine to medium sand particles	W=19.6%; G=0.4%; S=53.9%; F=45.7%
80									Bottom of Exploration at 80' 8/2/2022 Groundwater observed at ~10' bgs at drilling completion
4545									

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Project: Provo Water Treatment Plant	Log of Boring DH22-WTP-03
Project Location: Provo, UT	Sheet 1 of 3
Project Number: 60670884	

Date(s) Drilled: 7/28/2022 - 8/1/2022	Drill Rig Type: FRASTE MD-XL (Track; SN: 574704)	Logged By: BB	Checked By: ER
Drilling Contractor: ConeTec	Hammer Information: 140-pound Automatic Hammer, 30-inch drop, ETR = 83%	Total Depth of Borehole: 81 feet	
Drilling Method: ODEX, Mud Rotary Bit Size/Type: ODEX (4-1/2"); Tricone (3-7/8")	Borehole Backfill: Soil cement	Surface Elevation: 4624.3 feet	
Sampling Method(s): 24" SPT, 3" OD Shelby Tube	Estimated Groundwater Level at Time of Drilling: 15 feet	Groundwater Level and Date Measured: Not Measured	
Location: N 7264024.3 ft, E 1595142.3 ft		Survey Datum: NAD83 State Plane Utah Central; NAVD88	

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
0				5 3 7 5 N=10	11	21	88	4 inches of TOPSOIL	
		SPT-01						FILL: Silty SAND (SM), medium dense, slightly moist, dark brown	
				4 3 7 27 N=10	11	16	42	NATIVE: Sandy SILT (ML), stiff, slightly moist to moist, very dark brown; low plasticity fines	
4620		SPT-02						Poorly graded GRAVEL with silt (GP-GM), very dense, slightly moist, gray brown; contains cobbles	Rock in bottom of sample SPT-02
5		SPT-03		22 50/5"	--	--	27		Rough drilling starting at 5'
4615									
10		SPT-04		20 36 28 25 N=64	77	87	46	...slightly moist to moist, very dark brown to very dark gray; trace clay in lower 4 inches of sample	
4610									
15		SPT-05		14 8 7 22 N=15	20	21	54	Silty GRAVEL (GM), medium dense, wet, dark brown	Groundwater observed during drilling at ~15' bgs W=4.4%; G=50.4%; S=6.4%; F=43.2%
4605									Softer soil drilling below 18.5'
20		SPT-06A SPT-06B		8 6 6 8 N=12	16	16	100	Silty SAND (SM), medium dense, wet, dark brown; fine to coarse sand particles, non-plastic fines	
								Sandy SILT (ML), very stiff, wet, dark brown to very dark gray; seams of silty clay up to 1/2 inch thick	NP; G=0%; S=37%; F=63.0%
								Silty SAND (SM), medium dense, wet, very dark gray; mostly fine sand particles	After SPT-06 augers were pulled and casing was set to 20'; mud rotary drilling began at 20'
4600				4 6					Casing was extended to 24' on 7/29 NP; G=0%; S=56.7%; F=43.3%
25									

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-WTP-03

Sheet 2 of 3

Elevation feet	Depth, feet	SAMPLES						Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount	Recovery, %				
	25	SPT-07	8 10 N=14	19	18	71				
		SPT-08A SPT-08B	5 5 6 N=11	15	14	92		Lean CLAY (CL), stiff, wet, very dark gray; some silt and sand	LL=26; PI=8; G=0%; S=8%; F=92.0% At 27': PP=0.6 tsf	
4595	30									
		S SH-01				100				Pushed Shelby tube at 11:05; retrieved at 11:25 W=29.1%; Test on silty material: NP: γ_d =94.3 pcf; Test on clay: CONS At 34': TV=0.62 tsf PP=1.6-1.75 tsf
	35									
		SPT-09	2 3 5 6 N=8	11	10	100		...medium plasticity fines	LL=33; PI=16; G=0%; S=3.0%; F=97.0% At 36': PP=1.25-1.6 tsf	
		SPT-10	15 12 15 19 N=27	38	32	79		SILT (ML), hard to very stiff, wet, very dark gray; fine sand particles	NP At 39': PP=2.25-3.5 tsf	
4585	40	SPT-11	7 12 11 12 N=23	32	27	88		...trace organics	NP At 41': PP=3.5 tsf	
		SPT-12A SPT-12B	9 15 14 14 N=29	41	34	92		...9-inch-thick layer with seams of silty clay to lean clay	At 43-43.5' PP=1.75-3.0 tsf	
	45	SPT-13A SPT-13B	5 11 15 19 N=26	37	30	92		...6-inch-thick layer with higher sand content	W=24.3%; NP; G=0%; S=7.7%; F=92.3% At 45': PP=3.5 tsf	
4575	50	SPT-14A SPT-14B	6 10 18 15 N=28	39	31	83		Silty SAND (SM), dense, wet, very dark gray; fine sand particles	NP; G=0%; S=5%; F=95.0% At 49.5': PP=1.5 tsf	
								Sandy SILT (ML), very stiff, moist to wet, very dark gray; fine sand particles		
	4570	S							At 54': PP=2.0-3.0 tsf Pushed Shelby tube at 13:10;	
55										

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Project: Provo Water Treatment Plant

Project Location: Provo, UT

Project Number: 60670884

Log of Boring DH22-WTP-03

Sheet 3 of 3

Elevation feet	Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
		Type	Number	Blows/6inch	SPT N ₆₀ blowcount	SPT (N ₁) ₆₀ blowcount			
55		SH-02						Lean CLAY (CL), stiff to very stiff, moist to wet, very dark gray; contains silt and fine sand particles	retrieved at 13:45 Test on clay: W=29.0%; LL=33; PI=13; γ_s =94.3 pcf; CONS At 55.9': TV=0.6 tsf PP=2.5-3.0 tsf
4565									
60		SH-03						...moist, occasional seams of sandy silt; some organic material	Pushed Shelby tube at 14:10; retrieved at 14:25 LL=31; PI=12; CONS
4560									At 63.9': TV=0.8 tsf PP=2.5 tsf
65									
4555	70	SPT-15		28 37 38 41 N=75	106	74	75	Poorly graded SAND with silt (SP-SM), very dense, moist to wet, very dark gray; fine to medium sand particles	
4550	75	SPT-16		19 25 27 39 N=52	73	50	79	Sandy SILT (ML), hard, moist to wet, very dark gray; non-plastic fines, fine sand particles, high sand content	
								...slightly lower sand content for bottom 3 inches of sample; low plasticity fines	
4545	80	SPT-17		14 31 32 36 N=63	89	59	88	...occasional layers of silty fine sand up to 2 inches thick; frequent seams and layers of lean clay up to 1 inch thick between 79.0- 79.5' (discarded)	
4540									Bottom of Exploration at 81' 16:15 on 7/29/2022

Appendix C Cone Penetration Test Results



PRESENTATION OF SITE INVESTIGATION RESULTS

Provo WTP

Prepared for:

AECOM

ConeTec Job No: 22-52-24382

Project Start Date: 2022-Jun-27

Project End Date: 2022-Jun-28

Report Date: 2022-Jul-11

Prepared by:

ConeTec Inc.

3750 West 500 South, Salt Lake City, UT 84104

Tel: (801) 973-3801

Fax: (801) 973-3802

ConeTecSLC@conetec.com

www.conetec.com

www.conetecdataservices.com



ABOUT THIS REPORT

The enclosed report presents the results of the site investigation program conducted by ConeTec, Inc. The program consisted of Seismic Piezocone Penetration Testing and Pore Pressure Dissipation Testing. Please note that this report, which also includes all accompanying data, are subject to the 3rd Party Disclaimer and Client Disclaimer that follow in the 'Limitations' section of this report.

Project Information

Client	AECOM
Project	Provo WTP
ConeTec Project Number	22-52-24382
Rig Description	25-ton Truck CPT Rig (C-7A)

Coordinates

Collection Method	USB/Serial GPS
EPSG Number	4326 (WGS 84 / LatLong)

Cone Penetration Test (CPTu)

Depth Reference	Existing ground surface at the time of the investigation
Sleeve data offset	0.1 Meters

Please refer to the list of attached documents following the text of this report. A test summary, location map, and plots are included. Thank you for the opportunity to work on this project.

LIMITATIONS

3rd Party Disclaimer

- The “Report” refers to this report titled Provo WTP
- The Report was prepared by ConeTec for AECOM

The Report is confidential and may not be distributed to or relied upon by any third parties without the express written consent of ConeTec. Any third parties gaining access to the Report do not acquire any rights as a result of such access. Any use which a third party makes of the Report, or any reliance on or decisions made based on it, are the responsibility of such third parties. ConeTec accepts no responsibility for loss, damage and/or expense, if any, suffered by any third parties as a result of decisions made, or actions taken or not taken, which are in any way based on, or related to, the Report or any portion(s) thereof.

Client Disclaimer

- ConeTec was retained by AECOM
- The “Report” refers to this report titled Provo WTP
- ConeTec was retained to collect and provide the raw data (“Data”) which is included in the Report.

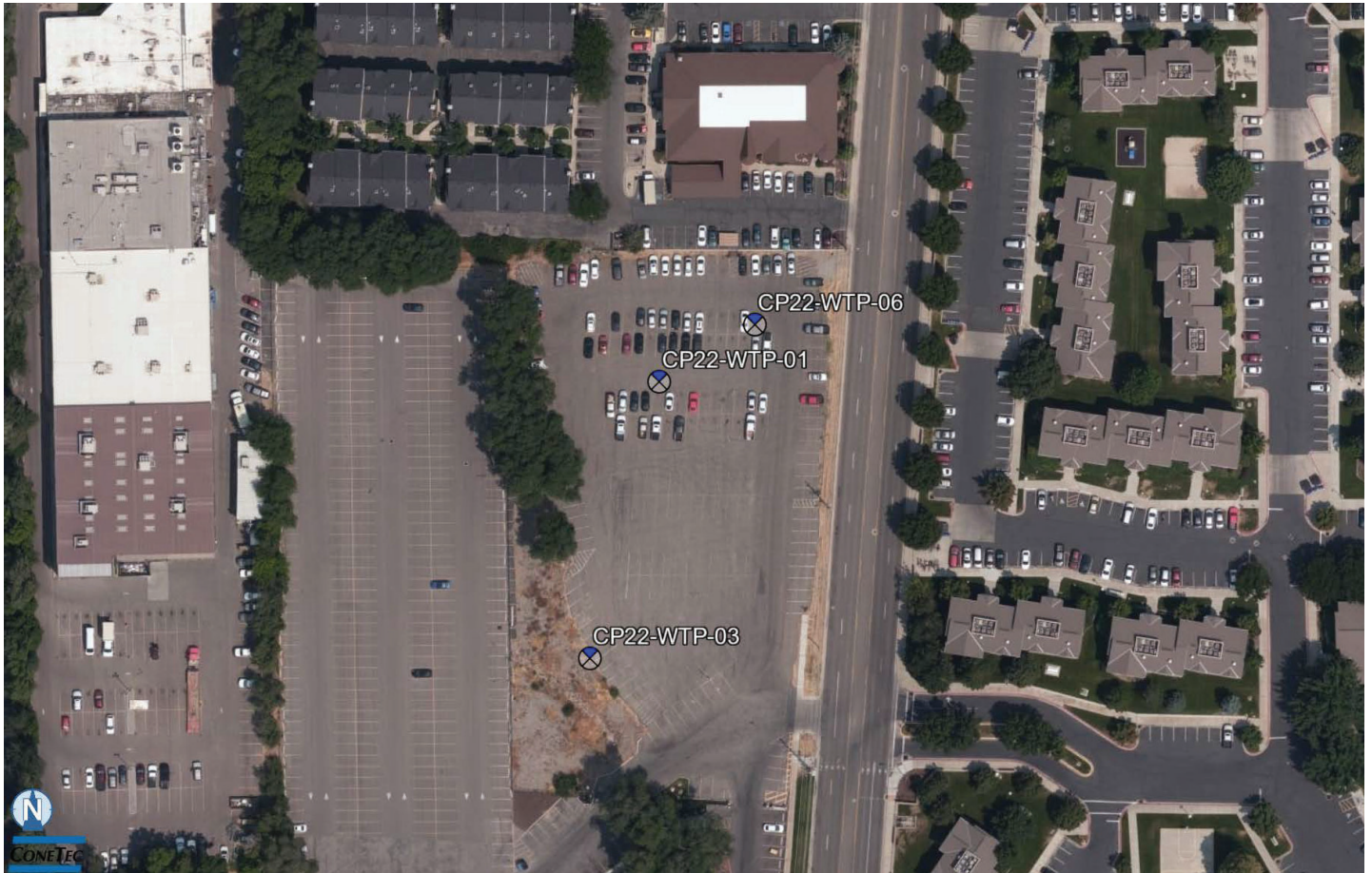
ConeTec has collected and reported the Data in accordance with current industry standards. No other warranty, express or implied, with respect to the Data is made by ConeTec. In order to properly understand the Data included in the Report, reference must be made to the documents accompanying and other sources referenced in the Report in their entirety. Other than the Data, the contents of the Report (including any Interpretations) should not be relied upon in any fashion without independent verification and ConeTec is in no way responsible for any loss, damage or expense resulting from the use of, and/or reliance on, such material by any party.

CONTENTS

The following listed below are included in the report:

- **Site Map**
- **Piezococone Penetration Test (CPTu) Sounding Summary**
- **CPTu Plots**
- **Pore Pressure Dissipation (PPD) Summary**
- **PPD Test Plots**
- **Seismic CPTu Results, Plots, and Traces**
- **Methodology Statements**
- **Data File Formats**

SITE MAP



ConeTec Job Number: 22-52-24382

Client: AECOM

Project: Provo WTP

Report Date: 2022-Jul-11

 **Sounding Location**

All sounding locations are approximate

Cone Penetration Test Summary and Standard Cone Penetration Test Plots



Job No: 22-52-24382
Client: AECOM
Project: Provo WTP
Start Date: 27-Jun-2022
End Date: 28-Jun-2022

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Cone Area (cm ²)	Final Depth (ft)	Latitude ¹	Longitude ¹	Elevation ² (ft)	Refer to Notation Number
CP22-WTP-01	22-52-24382_SP01	28-Jun-2022	EC773:T1500F15U35	15	120.08	40.262105	-111.662034	4627	
CP22-WTP-03	22-52-24382_CP03	27-Jun-2022	EC773:T1500F15U35	15	121.31	40.261523	-111.662224	4626	
CP22-WTP-06	22-52-24382_CP06	28-Jun-2022	EC773:T1500F15U35	15	74.15	40.262225	-111.661771	4631	

1. The coordinates were collected using consumer grade GPS and have an accuracy of ±30 feet. EPSG number: 4326 (WGS84 / LatLong).

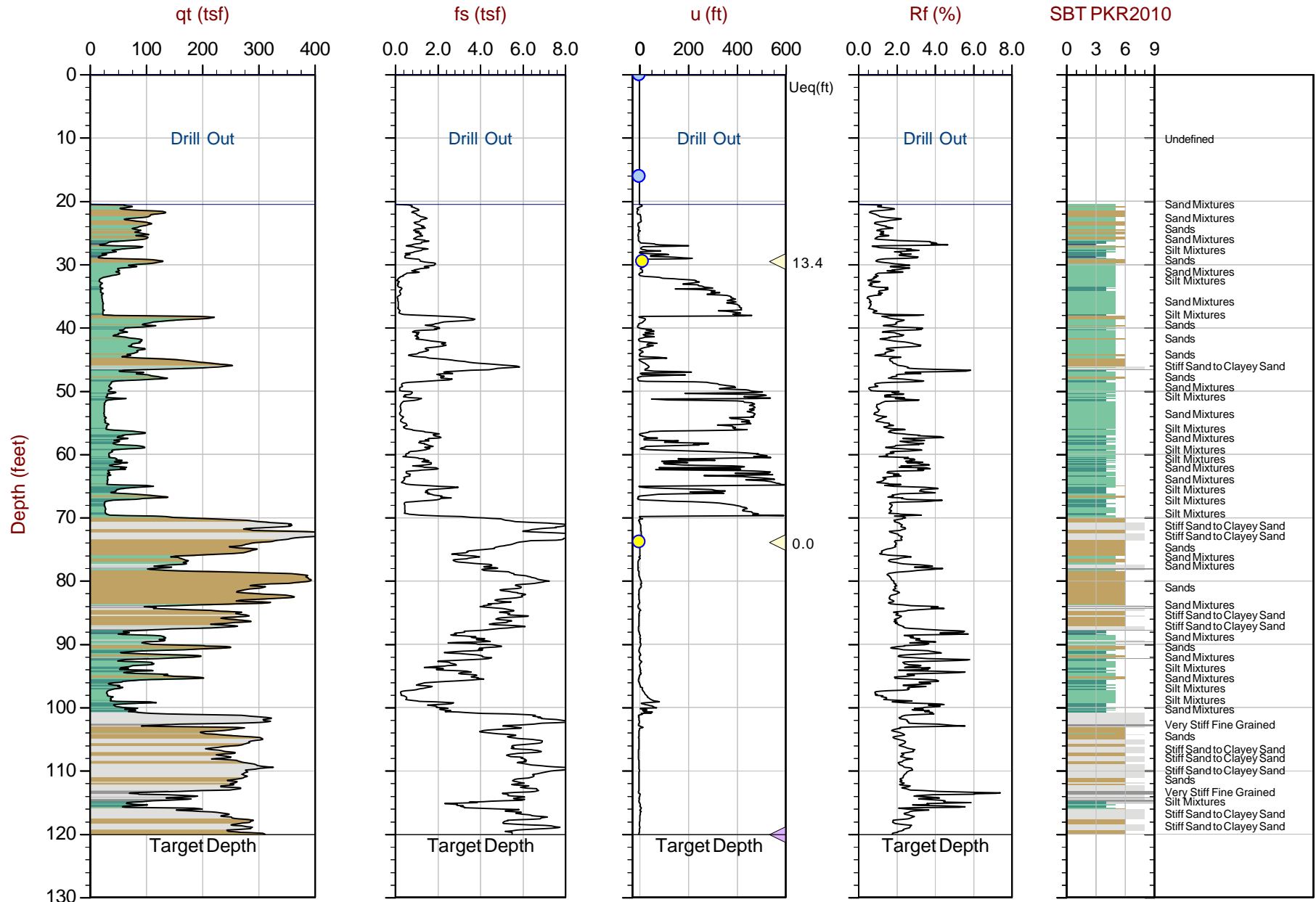
2. Elevations are referenced to the ground surface at the time of testing and were derived from the Google Earth elevation.



AECOM

Job No: 22-52-24382
Date: 2022-06-28 11:32
Site: Provo WTP

Sounding: CP22-WTP-01
Cone: 773:T1500F15U35



Max Depth: 36.600 m / 120.08 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 22-52-24382_SP01.COR

SBT: Robertson, 2010 (CPT'10)
Coords: Lat: 40.262105 Long: -111.662034
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved — Hydrostatic Line

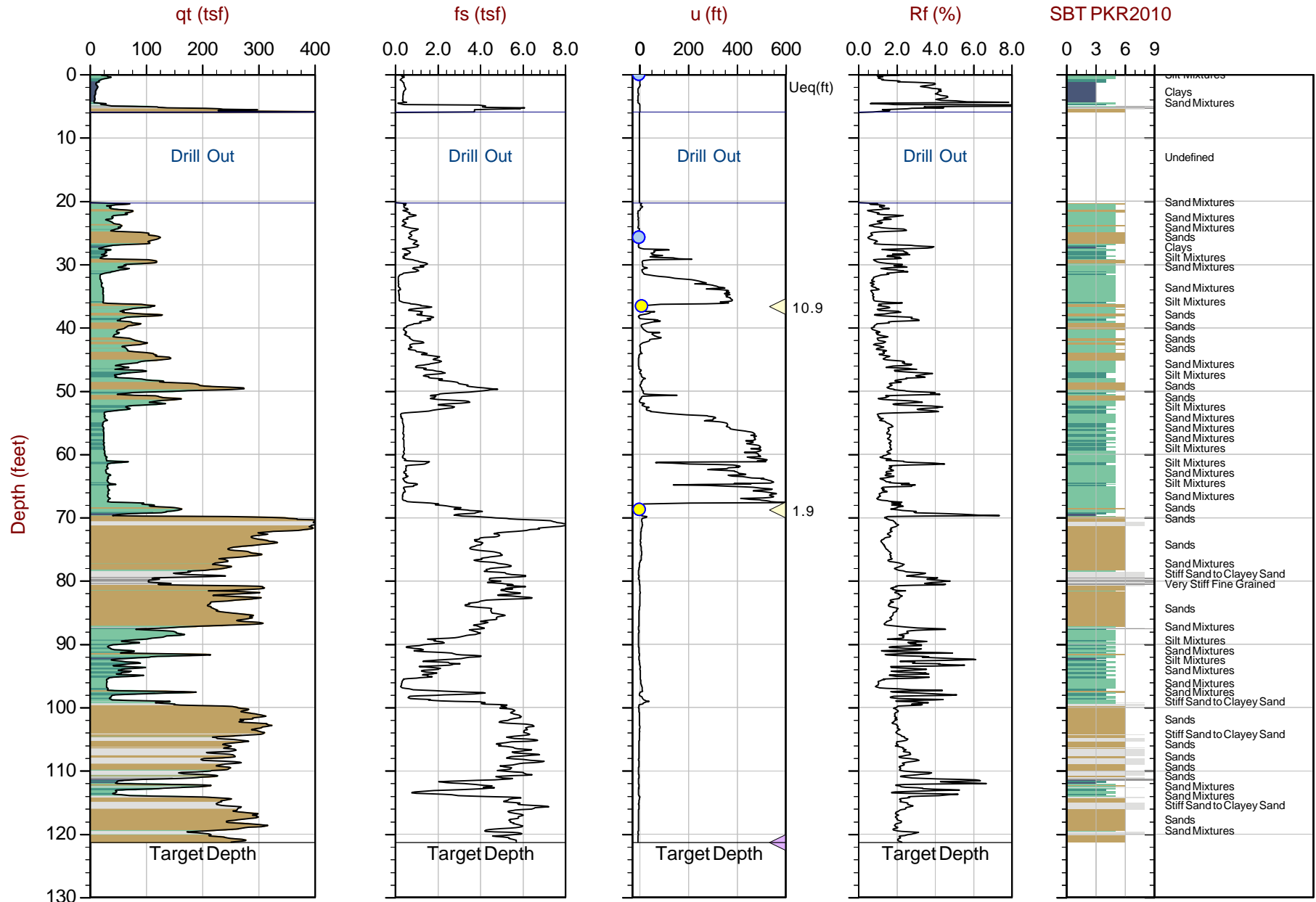
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.



AECOM

Job No: 22-52-24382
Date: 2022-06-27 09:32
Site: Provo WTP

Sounding: CP22-WTP-03
Cone: 773:T1500F15U35



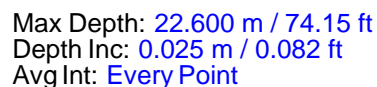
Max Depth: 36.975 m / 121.31 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 22-52-24382_CP03.COR

SBT: Robertson, 2010 (CPT'10)
Coords: Lat: 40.261523 Long: -111.662224
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.



SBT: [Robertson, 2010 \(CPT'10\)](#)
 Coords: [Lat: 40.262225](#) [Long: -111.661771](#)
 Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq)
 ● Assumed Ueq
 ◀ Dissipation, Ueq achieved
 ◀ Dissipation, Ueq not achieved
 — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots



Job No: 22-52-24382
Client: AECOM
Project: Provo WTP
Start Date: 27-Jun-2022
End Date: 28-Jun-2022

CPT_u PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm ²)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U _{eq} (ft.)	Calculated Phreatic Surface (ft.)	Refer to Notation Number
CP22-WTP-01	22-52-24382_SP01	15	400	29.53	13.4	16.1	
CP22-WTP-01	22-52-24382_SP01	15	400	73.90	0.0		
CP22-WTP-01	22-52-24382_SP01	15	500	120.08	Not Achieved		1
CP22-WTP-03	22-52-24382_CP03	15	700	36.66	10.9	25.8	
CP22-WTP-03	22-52-24382_CP03	15	700	68.81	1.9	66.9	
CP22-WTP-03	22-52-24382_CP03	15	500	121.31	Not Achieved		1
CP22-WTP-06	22-52-24382_CP06	15	400	35.35	11.5	23.9	
CP22-WTP-06	22-52-24382_CP06	15	1000	67.99	5.6	62.4	

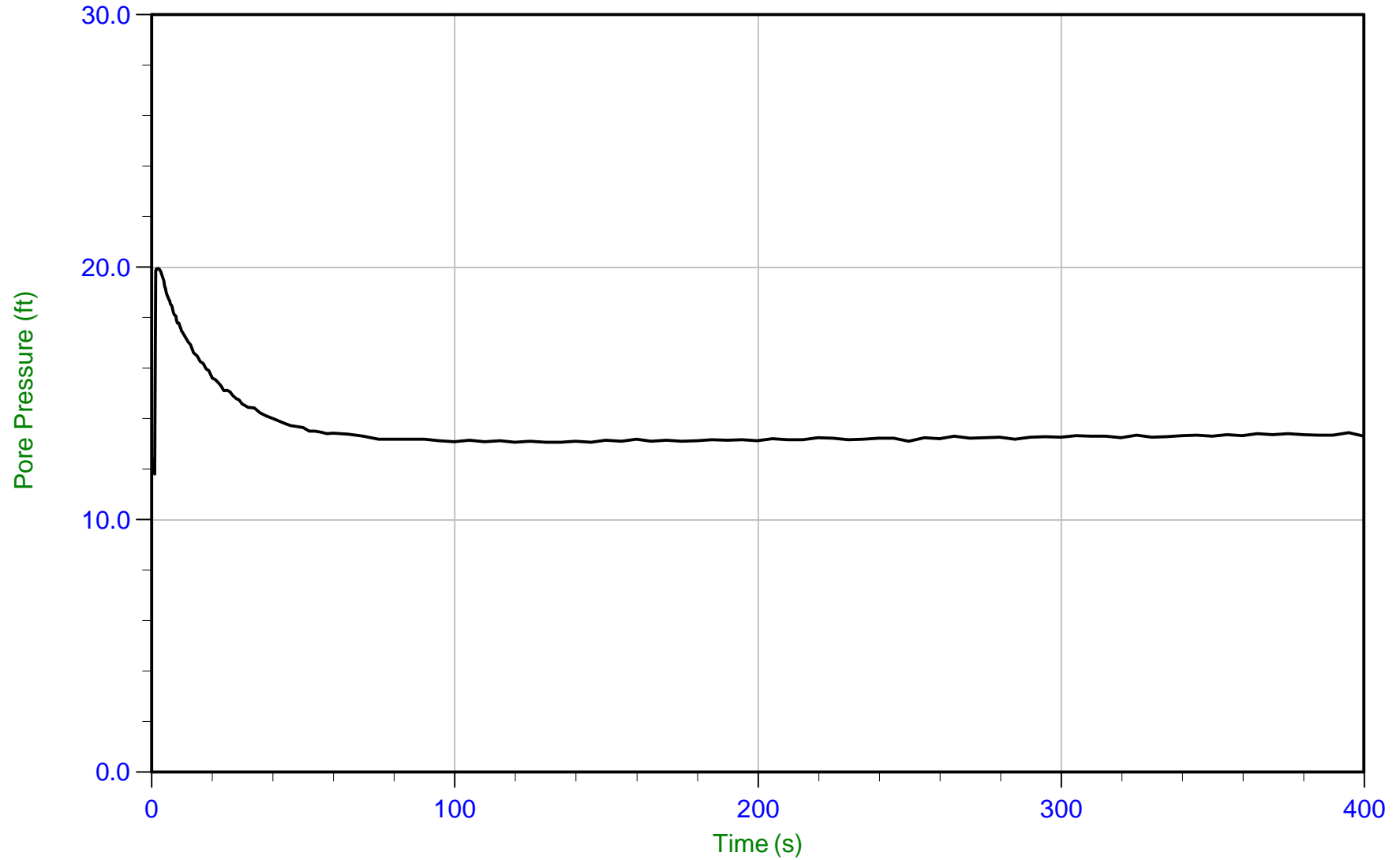
1. Pore pressure dissipation test ended by the client.



AECOM

Job No: 22-52-24382
Date: 06/28/2022 11:32
Site: Provo WTP

Sounding: CP22-WTP-01
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_SP01.PPD2
Depth: 9.000 m / 29.527 ft
Duration: 400.0 s

u Min: 11.8 ft
u Max: 20.0 ft
u Final: 13.3 ft

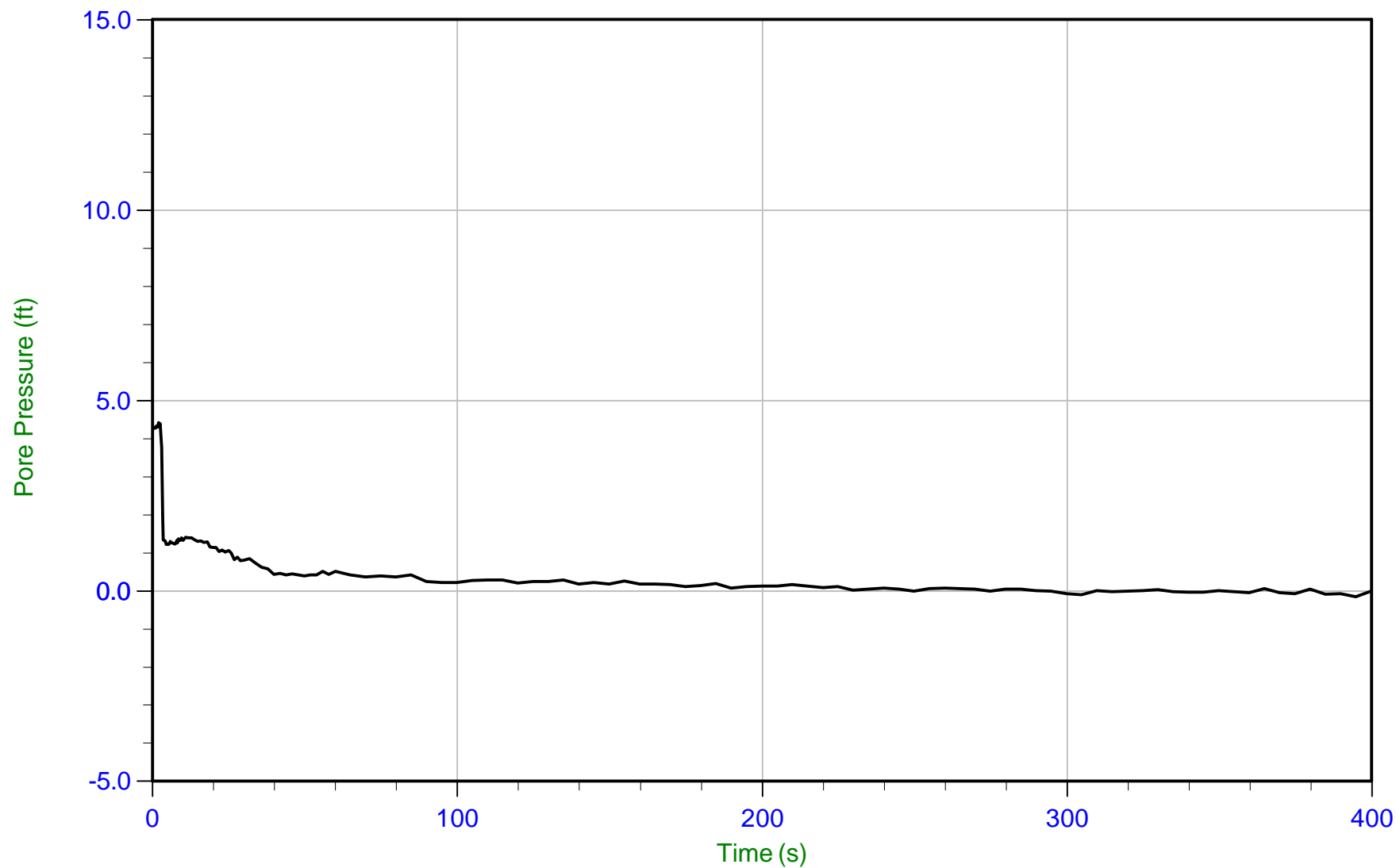
WT: 4.921 m / 16.145 ft
Ueq: 13.4 ft



AECOM

Job No: 22-52-24382
Date: 06/28/2022 11:32
Site: Provo WTP

Sounding: CP22-WTP-01
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_SP01.PPD2
Depth: 22.525 m / 73.900 ft
Duration: 400.0 s

u Min: -0.2 ft
u Max: 4.4 ft
u Final: -0.0 ft

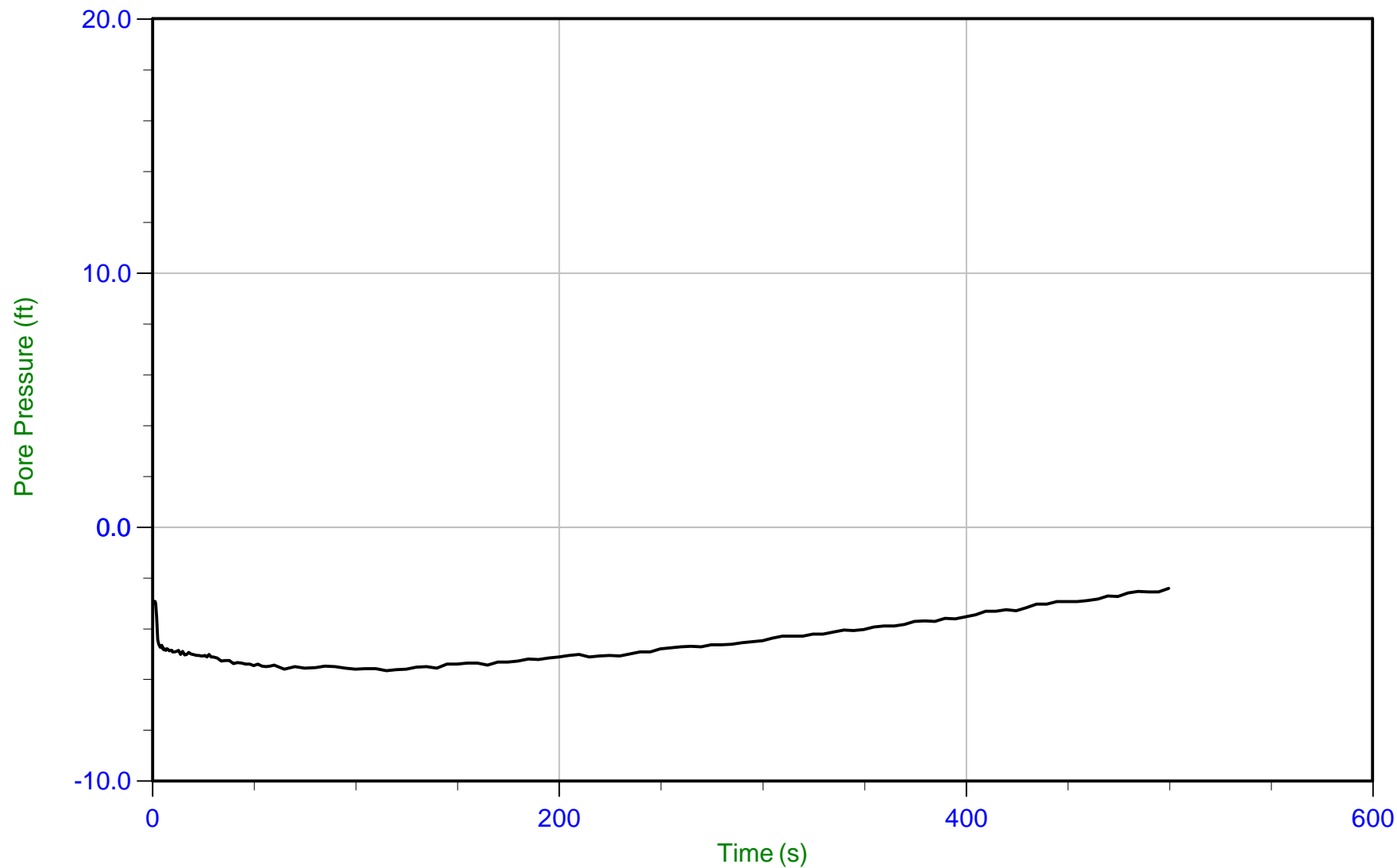
WT: 22.525 m / 73.900 ft
Ueq: 0.0 ft



AECOM

Job No: 22-52-24382
Date: 06/28/2022 11:32
Site: Provo WTP

Sounding: CP22-WTP-01
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_SP01.PPD2
Depth: 36.600 m / 120.077 ft
Duration: 500.0 s

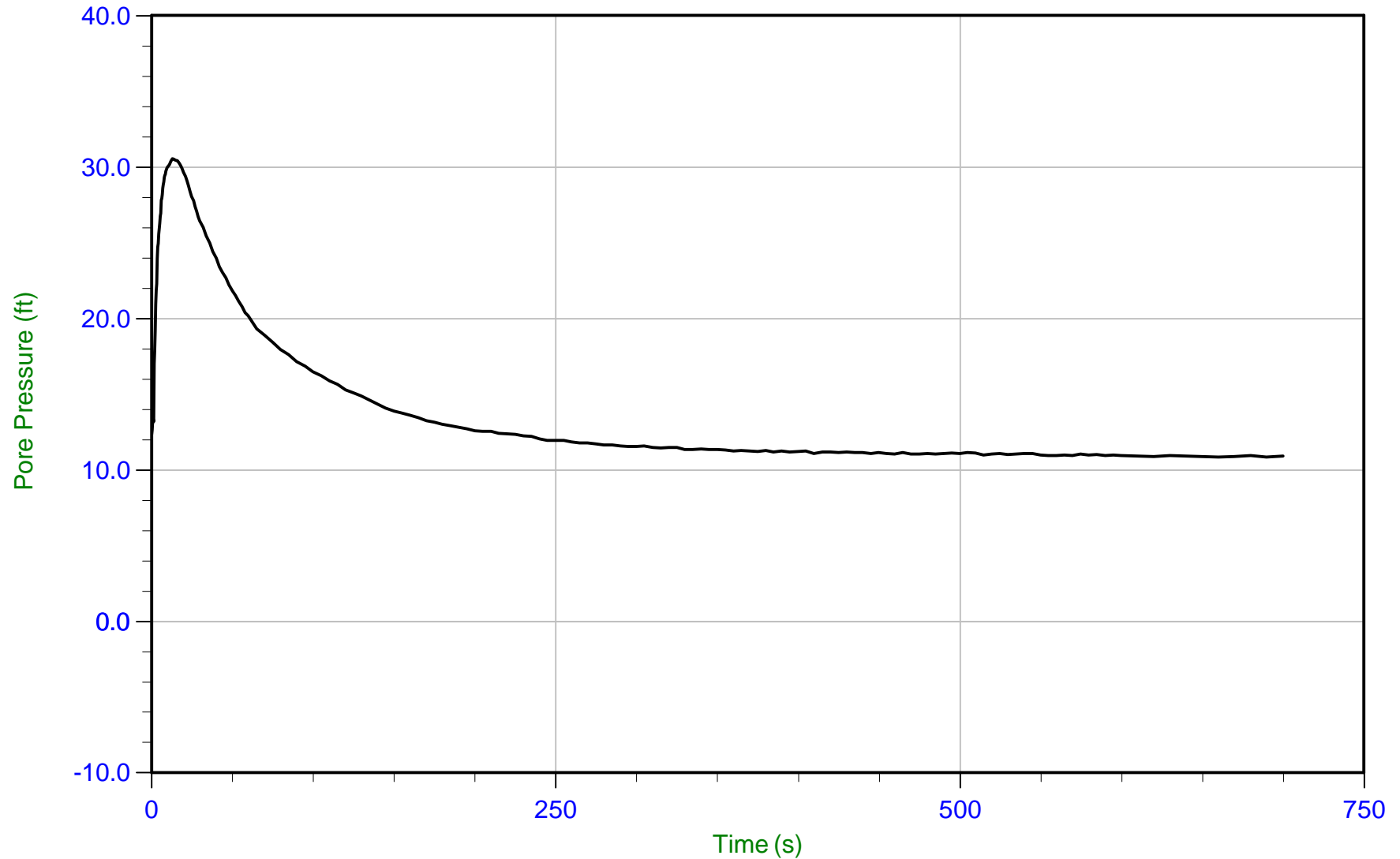
u Min: -5.6 ft
u Max: -2.4 ft
u Final: -2.4 ft



AECOM

Job No: 22-52-24382
Date: 06/27/2022 10:05
Site: Provo WTP

Sounding: CP22-WTP-03
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP03.PPD2
Depth: 11.175 m / 36.663 ft
Duration: 700.0 s

u Min: 10.9 ft
u Max: 30.6 ft
u Final: 10.9 ft

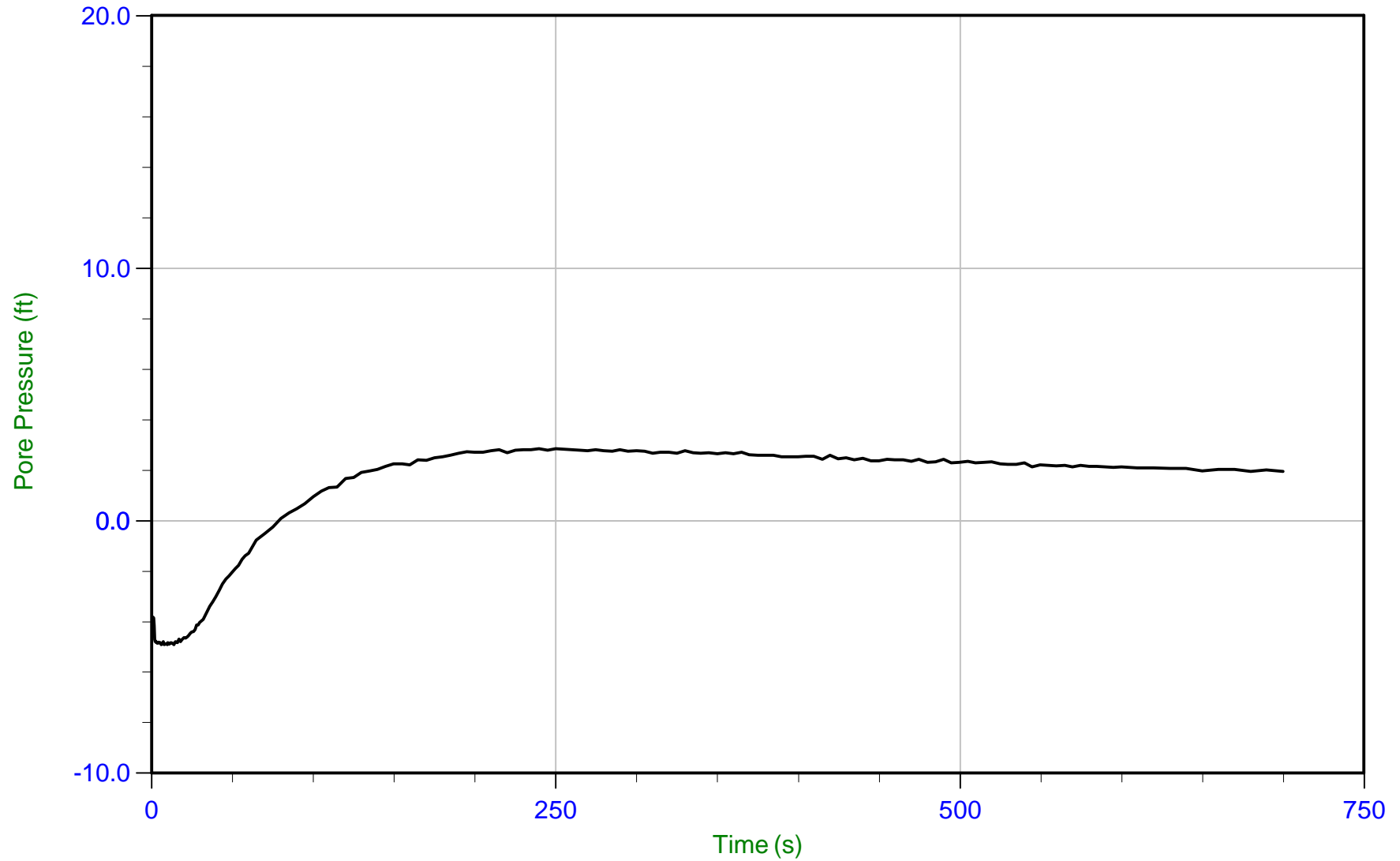
WT: 7.855 m / 25.770 ft
Ueq: 10.9 ft



AECOM

Job No: 22-52-24382
Date: 06/27/2022 10:05
Site: Provo WTP

Sounding: CP22-WTP-03
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP03.PPD2
Depth: 20.975 m / 68.815 ft
Duration: 700.0 s

u Min: -4.9 ft
u Max: 2.9 ft
u Final: 1.9 ft

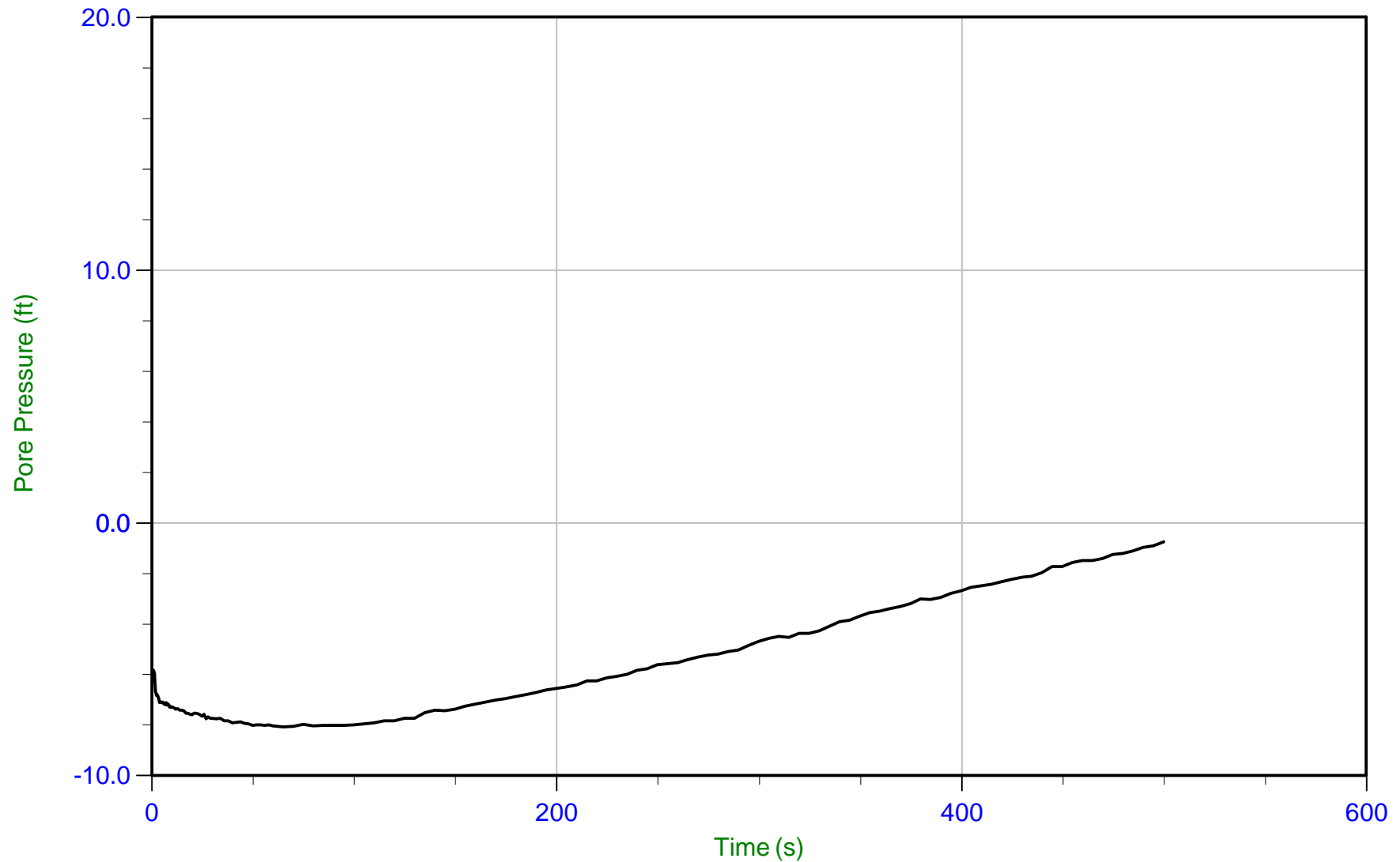
WT: 20.395 m / 66.911 ft
Ueq: 1.9 ft



AECOM

Job No: 22-52-24382
Date: 06/27/2022 10:05
Site: Provo WTP

Sounding: CP22-WTP-03
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP03.PPD2
Depth: 36.975 m / 121.308 ft
Duration: 500.0 s

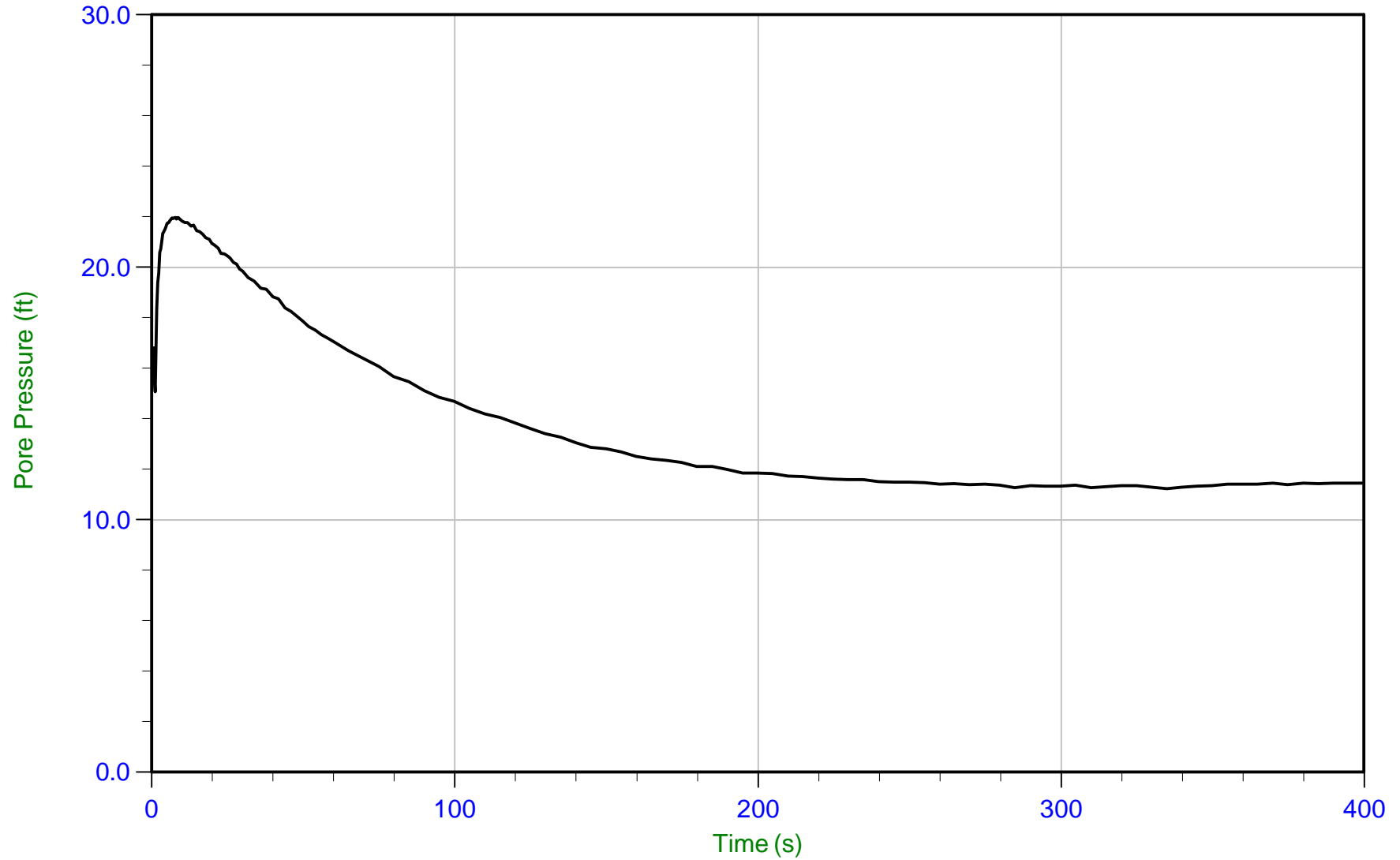
u Min: -8.1 ft
u Max: -0.7 ft
u Final: -0.7 ft



AECOM

Job No: 22-52-24382
Date: 06/28/2022 15:25
Site: Provo WTP

Sounding: CP22-WTP-06
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP06.PPD2
Depth: 10.775 m / 35.351 ft
Duration: 400.0 s

u Min: 11.2 ft
u Max: 22.0 ft
u Final: 11.5 ft

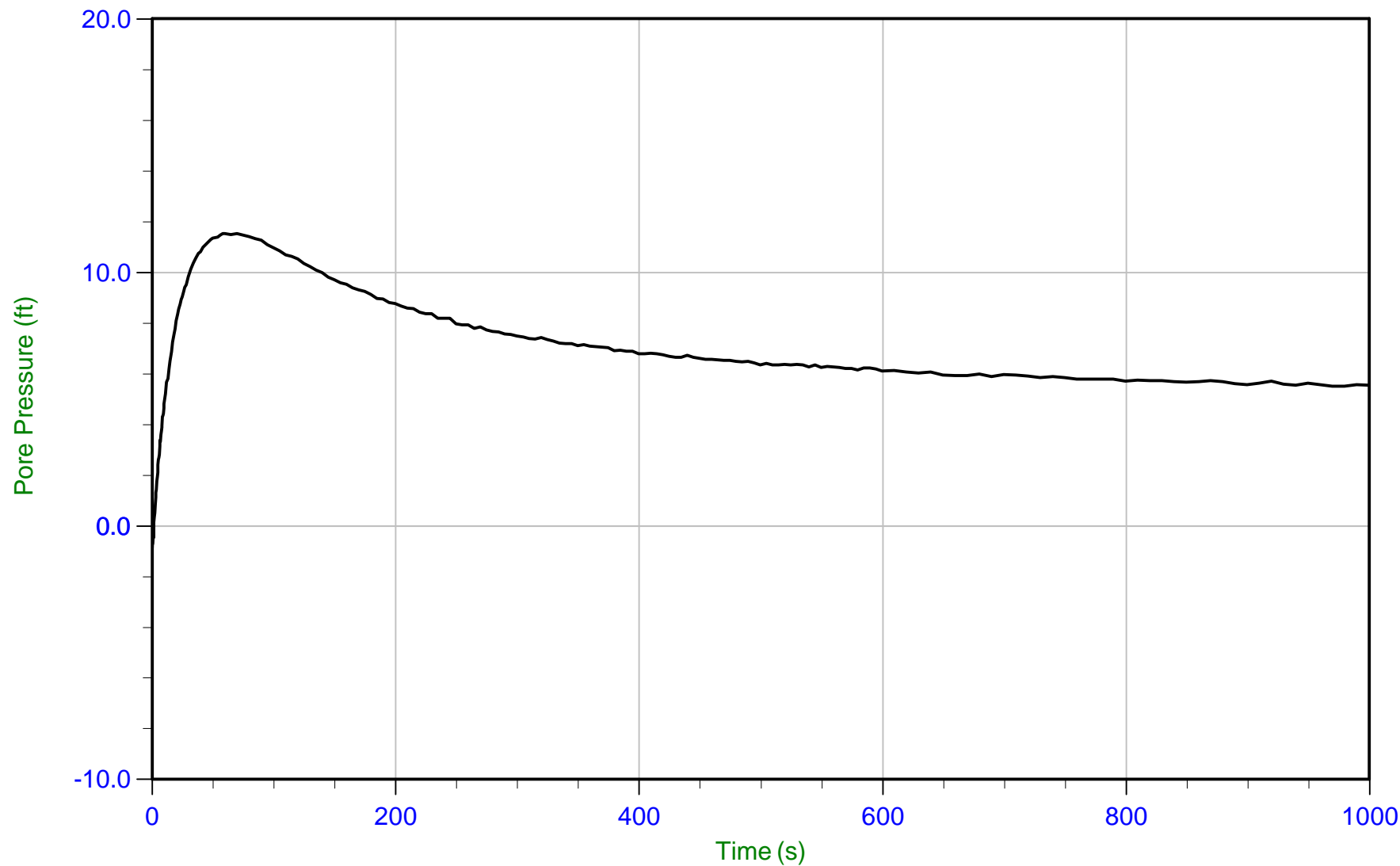
WT: 7.281 m / 23.887 ft
Ueq: 11.5 ft



AECOM

Job No: 22-52-24382
Date: 06/28/2022 15:25
Site: Provo WTP

Sounding: CP22-WTP-06
Cone: 773:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP06.PPD2
Depth: 20.725 m / 67.995 ft
Duration: 1000.0 s

u Min: -0.9 ft
u Max: 11.5 ft
u Final: 5.6 ft

WT: 19.020 m / 62.402 ft
Ueq: 5.6 ft

Seismic Cone Penetration Test Tabular Results



Job No: 22-52-24382
Client: AECOM
Project: Provo WTP
Sounding ID: CP22-WTP-01
Date: 06:28:22 11:28

Seismic Source: Beam
Seismic Offset (ft): 1.83
Source Depth (ft): 0.00
Geophone Offset (ft): 0.81

SCPT_u SHEAR WAVE VELOCITY TEST RESULTS - V_s

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
21.26	20.45	20.53			
24.61	23.79	23.86	3.33	5.10	654
27.89	27.08	27.14	3.27	4.68	700
31.17	30.36	30.41	3.27	4.19	781
34.45	33.64	33.69	3.28	4.62	709
37.73	36.92	36.96	3.28	3.79	864
41.01	40.20	40.24	3.28	3.93	834
44.29	43.48	43.52	3.28	3.98	823
47.57	46.76	46.80	3.28	3.82	858
50.85	50.04	50.07	3.28	3.74	876
54.13	53.32	53.35	3.28	3.24	1014
57.42	56.60	56.63	3.28	3.58	916
60.70	59.88	59.91	3.28	3.58	915
63.98	63.16	63.19	3.28	3.34	981
67.26	66.45	66.47	3.28	3.45	950
70.54	69.73	69.75	3.28	3.55	923
73.89	73.07	73.10	3.35	2.95	1136
77.10	76.29	76.31	3.21	3.03	1062
80.38	79.57	79.59	3.28	3.24	1014
83.66	82.85	82.87	3.28	3.11	1056
86.94	86.13	86.15	3.28	3.22	1020
90.22	89.41	89.43	3.28	3.08	1064
93.50	92.69	92.71	3.28	3.15	1042
96.79	95.97	95.99	3.28	2.78	1180
100.07	99.25	99.27	3.28	3.13	1049
103.35	102.53	102.55	3.28	3.02	1087
106.63	105.82	105.83	3.28	3.10	1059
120.08	119.27	119.28	13.45	12.01	1120

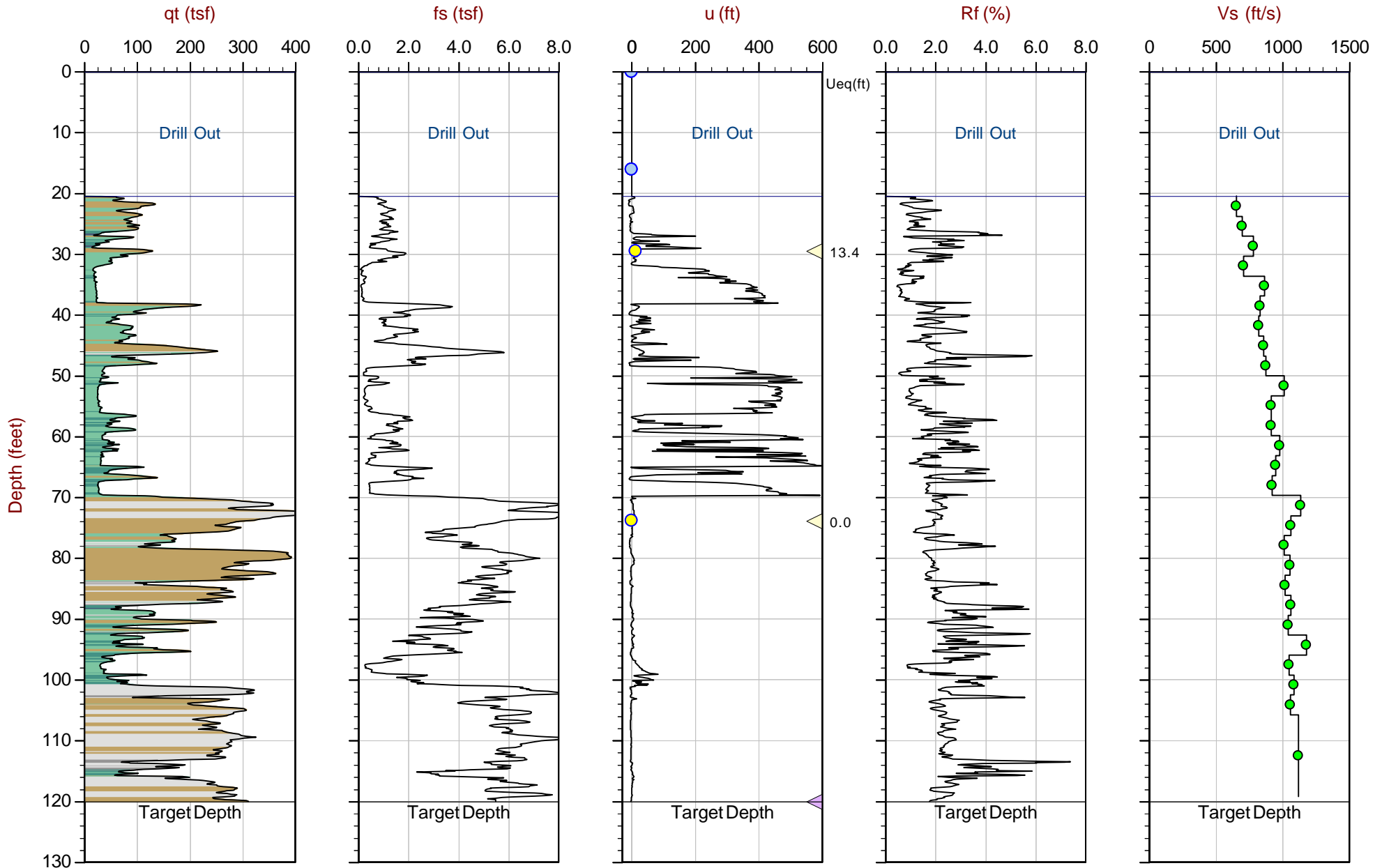
Seismic Cone Penetration Test Plots



AECOM

Job No: 22-52-24382
Date: 2022-06-28 11:32
Site: ProvoWTP

Sounding: CP22-WTP-01
Cone: 773:T1500F15U35



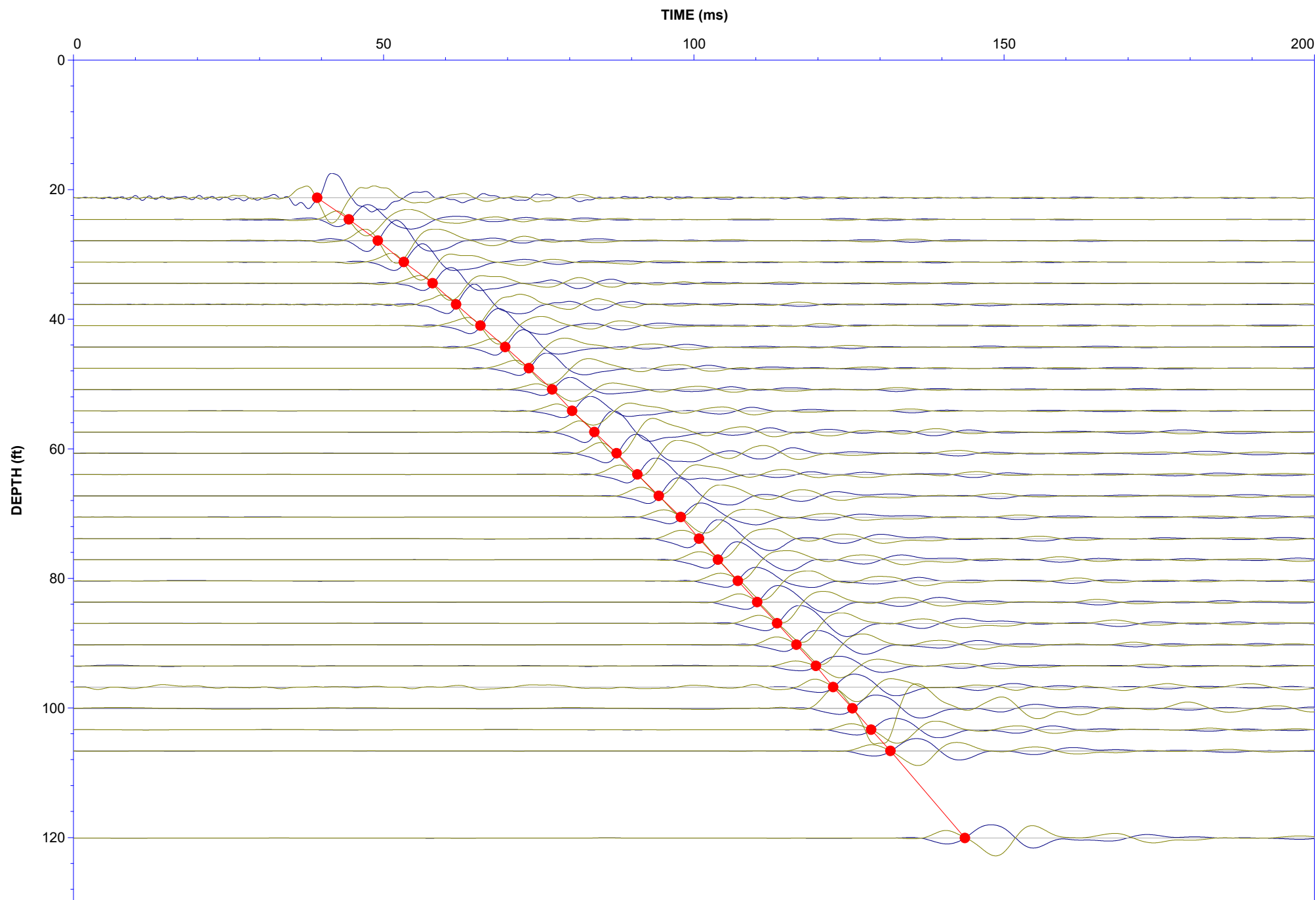
Max Depth: 36.600 m / 120.08 ft File: 22-52-24382_SP01.COR
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

SBT: Robertson, 2010 (CPT'10)
Coords: Lat: 40.262105 Long: -111.662034
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Shear Wave (V_s) Traces



Methodology Statements and Data File Formats

METHODOLOGY STATEMENTS



CONE PENETRATION TEST (CPTu) - eSeries

Cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd., a subsidiary of ConeTec.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and two geophone sensors for recording seismic signals. All signals are amplified and measured with minimum sixteen-bit resolution down hole within the cone body, and the signals are sent to the surface using a high bandwidth, error corrected digital interface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm² and 15 cm² tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table. The 15 cm² penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm² piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 millimeters diameter over a length of 32 millimeters with tapered leading and trailing edges) located at a distance of 585 millimeters above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u₂" position ([ASTM Type 2](#)). The filter is six millimeters thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current [ASTM D5778](#) standard. ConeTec's calibration criteria also meets or exceeds those of the current [ASTM D5778](#) standard. An illustration of the piezocone penetrometer is presented in [Figure CPTu](#).

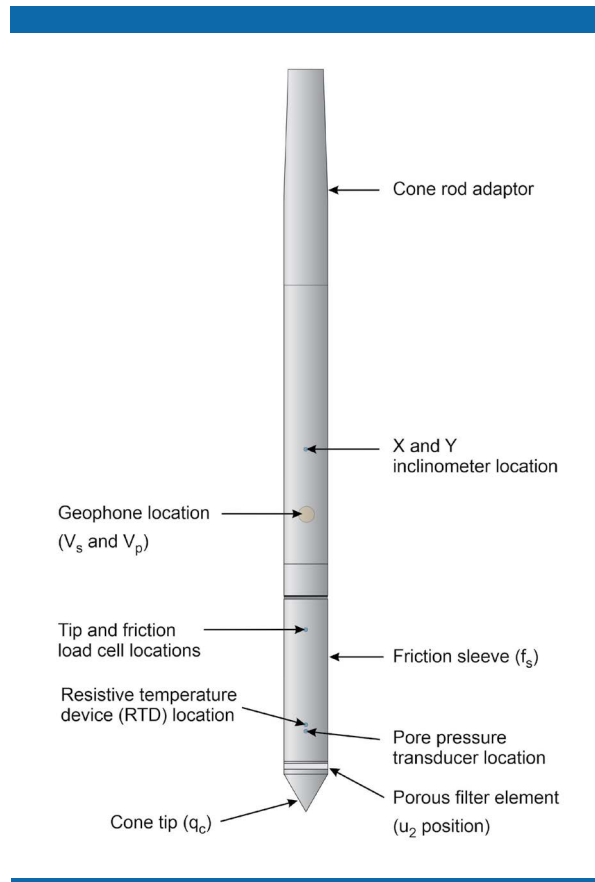


Figure CPTu. Piezocone Penetrometer (15 cm²)

The ConeTec data acquisition system consists of a Windows based computer, signal interface box, and power supply. The signal interface combines depth increment signals, seismic trigger signals and the downhole digital data. This combined data is then sent to the Windows based computer for collection and presentation. The data is recorded at fixed depth increments using a depth encoder that is either portable or integrated into the rig. The typical recording interval is 2.5 centimeters; custom recording intervals are possible.

The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPTu operating procedures which are in general accordance with the current [ASTM D5778](#) standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of two centimeters per second, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil under vacuum pressure prior to use
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with [ASTM](#) standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by [Robertson, P.K., 2010](#). The Soil Behavior Type (SBT) classification chart developed by [Robertson, P.K., 2010](#) is presented in [Figure SBT](#). It should be noted that it is not always possible to accurately identify a soil behavior type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behavior type.

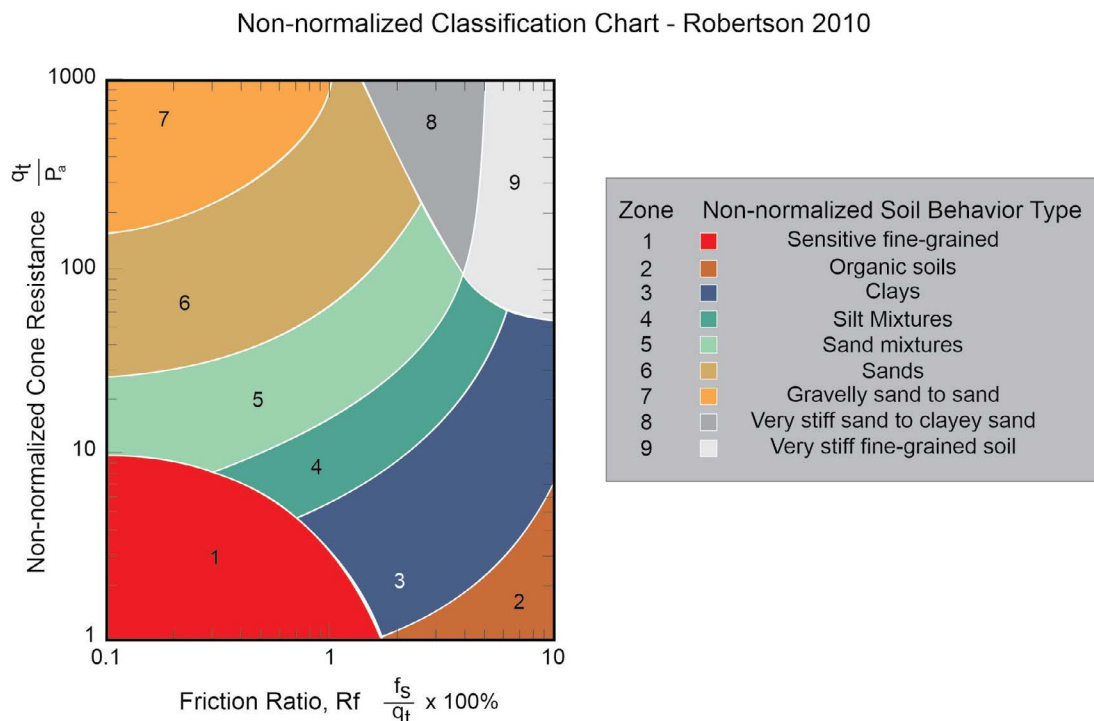


Figure SBT. Non-Normalized Soil Behavior Type Classification Chart (SBT)

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in [Robertson et al. \(1986\)](#):

$$q_t = q_c + (1-a) \cdot u_2$$

where: q_t is the corrected tip resistance

q_c is the recorded tip resistance

u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)

a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (R_f) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

For additional information on CPTu interpretations and calculated geotechnical parameters, refer to [Robertson et al. \(1986\)](#), [Lunne et al. \(1997\)](#), [Robertson \(2009\)](#), [Mayne \(2013, 2014\)](#) and [Mayne and Peuchen \(2012\)](#).

REFERENCES

ASTM D5778-20, 2020, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: [10.1520/D5778-20](#).

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, "Cone Penetration Testing in Geotechnical Practice", Blackie Academic and Professional.

Mayne, P.W., 2013, "Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests", Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420. DOI: [10.1061/9780784412770.027](#).

Mayne, P.W. and Peuchen, J., 2012, "Unit weight trends with cone resistance in soft to firm clays", Geotechnical and Geophysical Site Characterization 4, Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.

Mayne, P.W., 2014, "Interpretation of geotechnical parameters from seismic piezocone tests", CPT'14 Keynote Address, Las Vegas, NV, May 2014.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, "Use of Piezometer Cone Data", Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 2009, "Interpretation of cone penetration tests – a unified approach", Canadian Geotechnical Journal, Volume 46: 1337-1355. DOI: [10.1139/T09-065](#).

Robertson, P.K., 2010. Soil behavior type from the CPT: an update. 2nd International Symposium on Cone Penetration Testing, CPT'10, Huntington Beach, CA, USA



PORE PRESSURE DISSIPATION TEST

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in [Figure PPD-1](#). For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

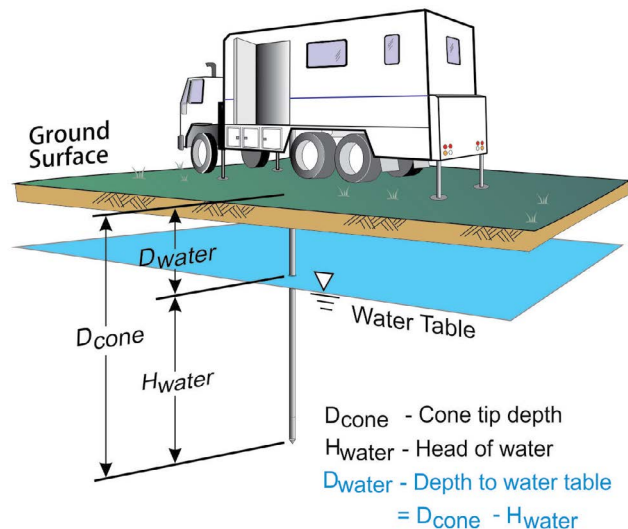


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behavior.

The typical shapes of dissipation curves shown in [Figure PPD-2](#) are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

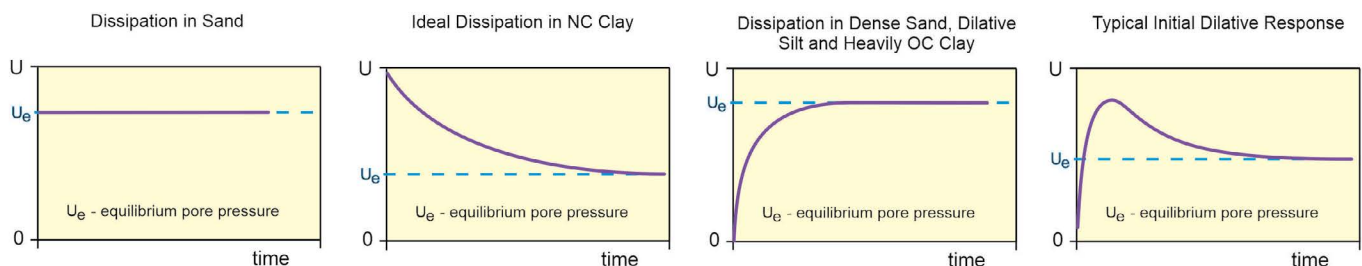


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve in [Figure PPD-2](#).



SEISMIC CONE PENETRATION TEST (SCPTu) - eSeries

Shear wave velocity (V_s) testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave velocity (V_p) testing is also performed.

ConeTec's piezocone penetrometers are manufactured with one horizontally active geophone (28 hertz) and one vertically active geophone (28 hertz). Both geophones are rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip. The vertically mounted geophone is more sensitive to compression waves.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances, an auger source or an imbedded impulsive source may be used for both shear waves and compression waves. The hammer and beam act as a contact trigger that initiates the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded in the memory of the cone using a fast analog to digital converter. The seismic trace is then transmitted digitally uphole to a Windows based computer through a signal interface box for recording and analysis. An illustration of the shear wave testing configuration is presented in [Figure SCPTu-1](#).

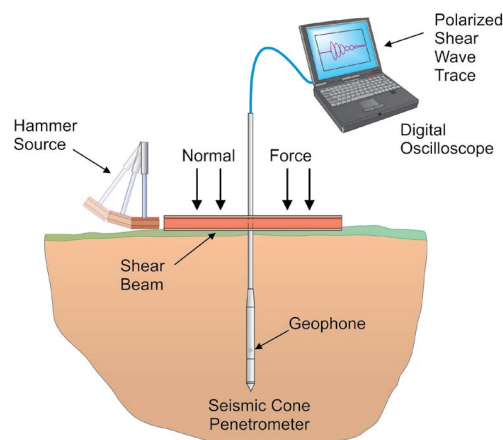


Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures which are in general accordance with the current [ASTM D5778](#) and [ASTM D7400](#) standards.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Typically, five wave traces for each orientation are recorded for quality control and uncertainty analysis purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). [Figure SCPTu-2](#) presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to [Robertson et al. \(1986\)](#).

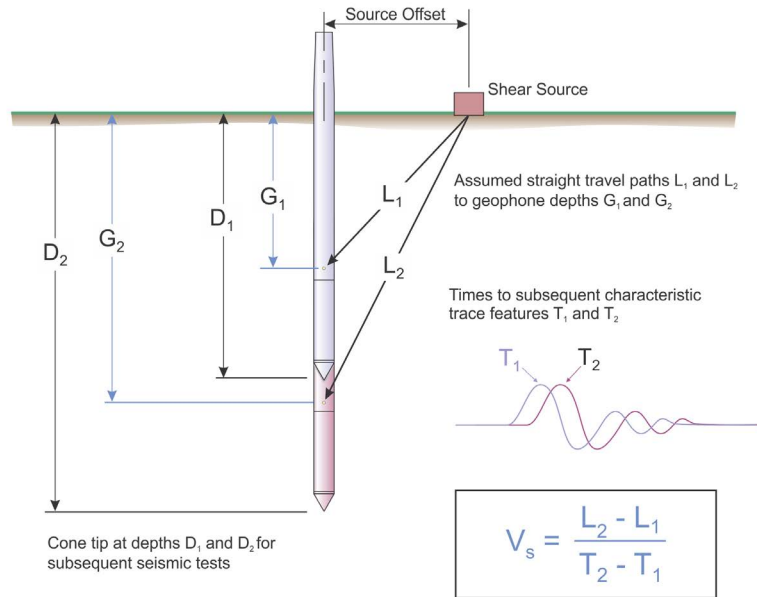


Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

REFERENCES

- ASTM D5778-20, 2020, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: [10.1520/D5778-20](https://doi.org/10.1520/D5778-20).
- ASTM D7400/D7400M-19, 2019, "Standard Test Methods for Downhole Seismic Testing", ASTM International, West Conshohocken, PA. DOI: [10.1520/D7400_D7400M-19](https://doi.org/10.1520/D7400_D7400M-19).
- Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, "Seismic CPT to Measure In-Situ Shear Wave Velocity", Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803. DOI: [10.1061/\(ASCE\)0733-9410\(1986\)112:8\(791\)](https://doi.org/10.1061/(ASCE)0733-9410(1986)112:8(791)).



CONE PENETRATION DIGITAL FILE FORMATS - eSeries

CPT Data Files (COR Extension)

ConeTec CPT data files are stored in ASCII text files that are readable by almost any text editor. ConeTec file names start with the job number (which includes the two digit year number) an underscore as a separating character, followed by two letters based on the type of test and the sounding ID. The last character position is reserved for an identifier letter (such as b, c, d etc) used to uniquely distinguish multiple soundings at the same location. The CPT sounding file has the extension COR. As an example, for job number 21-02-00001 the first CPT sounding will have file name 21-02-00001_CP01.COR

The sounding (COR) file consists of the following components:

1. Two lines of header information
2. Data records
3. End of data marker
4. Units information

Header Lines

Line 1: Columns 1-6 may be blank or may indicate the version number of the recording software

Columns 7-21 contain the sounding Date and Time (Date is MM:DD:YY)

Columns 23-38 contain the sounding Operator

Columns 51-100 contain extended Job Location information

Line 2: Columns 1-16 contain the Job Location

Columns 17-32 contain the Cone ID

Columns 33-47 contain the sounding number

Columns 51-100 may contain extended sounding ID information

Data Records

The data records contain 4 or more columns of data in floating point format. A comma and spaces separate each data item:

Column 1: Sounding Depth (meters)

Column 2: Tip (q_c), recorded in units selected by the operator

Column 3: Sleeve (f_s), recorded in units selected by the operator

Column 4: Dynamic pore pressure (u), recorded in units selected by the operator

Column 5: Empty or may contain other requested data such as Gamma, Resistivity or UVIF data

End of Data Marker

After the last line of data there is a line containing an ASCII 26 (CTL-Z) character (small rectangular shaped character) followed by a newline (carriage return / line feed). This is used to mark the end of data.

Units Information

The last section of the file contains information about the units that were selected for the sounding. A separator bar makes up the first line. The second line contains the type of units used for depth, q_c , f_s and u . The third line contains the conversion values required for ConeTec's software to convert the recorded data to an internal set of base units (bar for q_c , bar for f_s and meters for u). Additional lines intended for internal ConeTec use may appear following the conversion values.

CPT Data Files (XLS Extension)

Excel format files of ConeTec CPT data are also generated from corresponding COR files. The XLS files have the same base file name as the COR file with a -BSC suffix. The information in the file is presented in table format and contains additional information about the sounding such as coordinate information, and tip net area ratio.

The BSCI suffix is given to XLS files which are enhanced versions of the BSC files and include the same data records in addition to inclination data collected for each sounding.

CPT Dissipation Files (XLS Extension)

Pore pressure dissipation files are provided in Excel format and contain each dissipation trace that exceeds a minimum duration (selected during post-processing) formatted column wise within the spreadsheet. The first column (Column A) contains the time in seconds and the second column (Column B) contains the time in minutes. Subsequent columns contain the dissipation trace data. The columns extend to the longest trace of the data set.

Detailed header information is provided at the top of the worksheet. The test depth in meters and feet, the number of points in the trace and the particular units are all presented at the top of each trace column.

CPT Dissipation files have the same naming convention as the CPT sounding files with a "-PPD" suffix.

Data Records

Each file will contain dissipation traces that exceed a minimum duration (selected during post-processing) in a particular column. The dissipation pore pressure values are typically recorded at varying time intervals throughout the trace; rapidly to start and increasing as the duration of the test lengthens. The test depth in meters and feet, the number of points in the trace and the trace number are identified at the top of each trace column.

Cone Type Designations

Cone ID	Cone Description	Tip Cross Sect. Area (cm ²)	Tip Capacity (bar)	Sleeve Area (cm ²)**	Sleeve Capacity (bar)	Pore Pressure Capacity (bar)
EC###	A15T1500F15U35	15	1500	225	15	35
EC###	A15T375F10U35	15	375	225	10	35
EC###	A10T1000F10U35	10	1000	150	10	35

refers to the Cone ID number

**Outer Cylindrical Area



PRESENTATION OF SITE INVESTIGATION RESULTS

Provo WTP - Supplementary

Prepared for:

AECOM

ConeTec Job No: 22-52-24382

Project Start Date: 2022-Jul-29

Project End Date: 2022-Jul-29

Report Date: 2022-Aug-04

Prepared by:

ConeTec Inc.

3750 West 500 South, Salt Lake City, UT 84104

Tel: (801) 973-3801

Fax: (801) 973-3802

ConeTecSLC@conetec.com

www.conetec.com

www.conetecdataservices.com



ABOUT THIS REPORT

The enclosed report presents the results of the site investigation program conducted by ConeTec, Inc. The program consisted of Piezocone Penetration Testing and Pore Pressure Dissipation Testing. Please note that this report, which also includes all accompanying data, are subject to the 3rd Party Disclaimer and Client Disclaimer that follow in the 'Limitations' section of this report.

Project Information

Client	AECOM
Project	Provo WTP - Supplementary
ConeTec Project Number	22-52-24382
Rig Description	25-Ton Truck CPT Rig (C-7A)

Coordinates

Collection Method	USB/Serial GPS
EPSG Number	4326 (WGS 84 / LatLong)

Cone Penetration Test (CPTu)

Depth Reference	Existing ground surface at the time of the investigation
Sleeve data offset	0.1 Meters

Please refer to the list of attached documents following the text of this report. A test summary, location map, and plots are included. Thank you for the opportunity to work on this project.

LIMITATIONS

3rd Party Disclaimer

- The “Report” refers to this report titled Provo WTP - Supplementary
- The Report was prepared by ConeTec for AECOM

The Report is confidential and may not be distributed to or relied upon by any third parties without the express written consent of ConeTec. Any third parties gaining access to the Report do not acquire any rights as a result of such access. Any use which a third party makes of the Report, or any reliance on or decisions made based on it, are the responsibility of such third parties. ConeTec accepts no responsibility for loss, damage and/or expense, if any, suffered by any third parties as a result of decisions made, or actions taken or not taken, which are in any way based on, or related to, the Report or any portion(s) thereof.

Client Disclaimer

- ConeTec was retained by AECOM
- The “Report” refers to this report titled Provo WTP - Supplementary
- ConeTec was retained to collect and provide the raw data (“Data”) which is included in the Report.

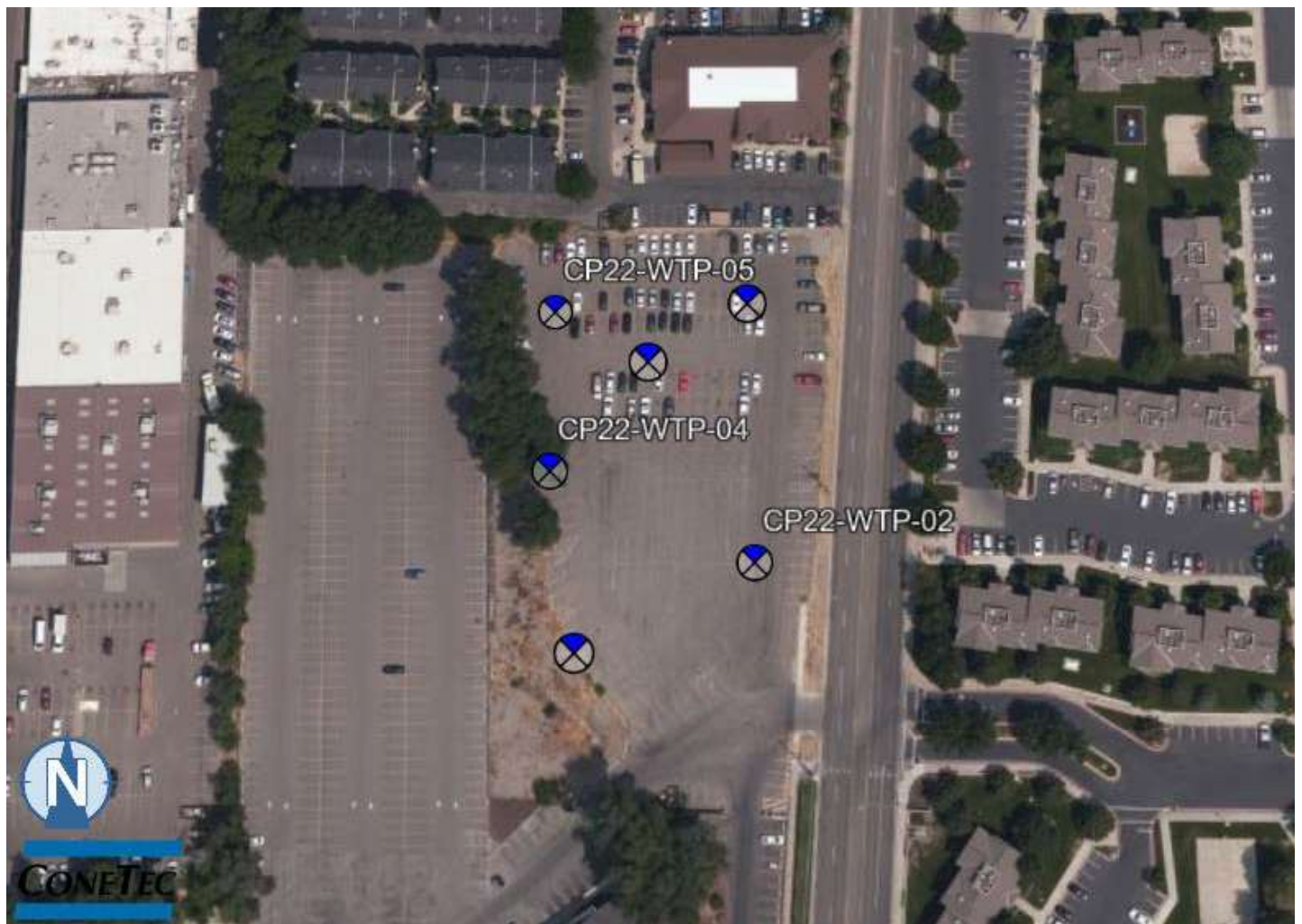
ConeTec has collected and reported the Data in accordance with current industry standards. No other warranty, express or implied, with respect to the Data is made by ConeTec. In order to properly understand the Data included in the Report, reference must be made to the documents accompanying and other sources referenced in the Report in their entirety. Other than the Data, the contents of the Report (including any Interpretations) should not be relied upon in any fashion without independent verification and ConeTec is in no way responsible for any loss, damage or expense resulting from the use of, and/or reliance on, such material by any party.

CONTENTS

The following listed below are included in the report:

- **Site Map**
- **Piezocone Penetration Test (CPTu) Sounding Summary**
- **CPTu Plots**
- **Pore Pressure Dissipation (PPD) Summary**
- **PPD Test Plots**
- **Methodology Statements**
- **Data File Formats**

SITE MAP



ConeTec Job Number: 22-52-24382

Client: AECOM

Project: Provo WTP - Supplementary

Report Date: 2022-Aug-04

 **Sounding Location**

All sounding locations are approximate

Cone Penetration Test Summary and Standard Cone Penetration Test Plots



Job No: 22-52-24382
Client: AECOM
Project: Provo WTP
Start Date: 29-Jul-2022
End Date: 29-Jul-2022

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Cone Area (cm ²)	Final Depth (ft)	Latitude ¹	Longitude ¹	Elevation ² (ft)	Refer to Notation Number
CP22-WTP-02	22-52-24382_CP02	29-Jul-2022	EC691:T1500F15U35	15	74.80	40.261700	-111.661759	4631	
CP22-WTP-04	22-52-24382_CP04	29-Jul-2022	EC691:T1500F15U35	15	71.19	40.261882	-111.662290	4631	
CP22-WTP-05	22-52-24382_CP05	29-Jul-2022	EC691:T1500F15U35	15	81.04	40.262208	-111.662280	4629	

1. The coordinates were collected using consumer grade GPS and have an accuracy of ±30 feet. EPSG number: 4326 (WGS84 / LatLong).

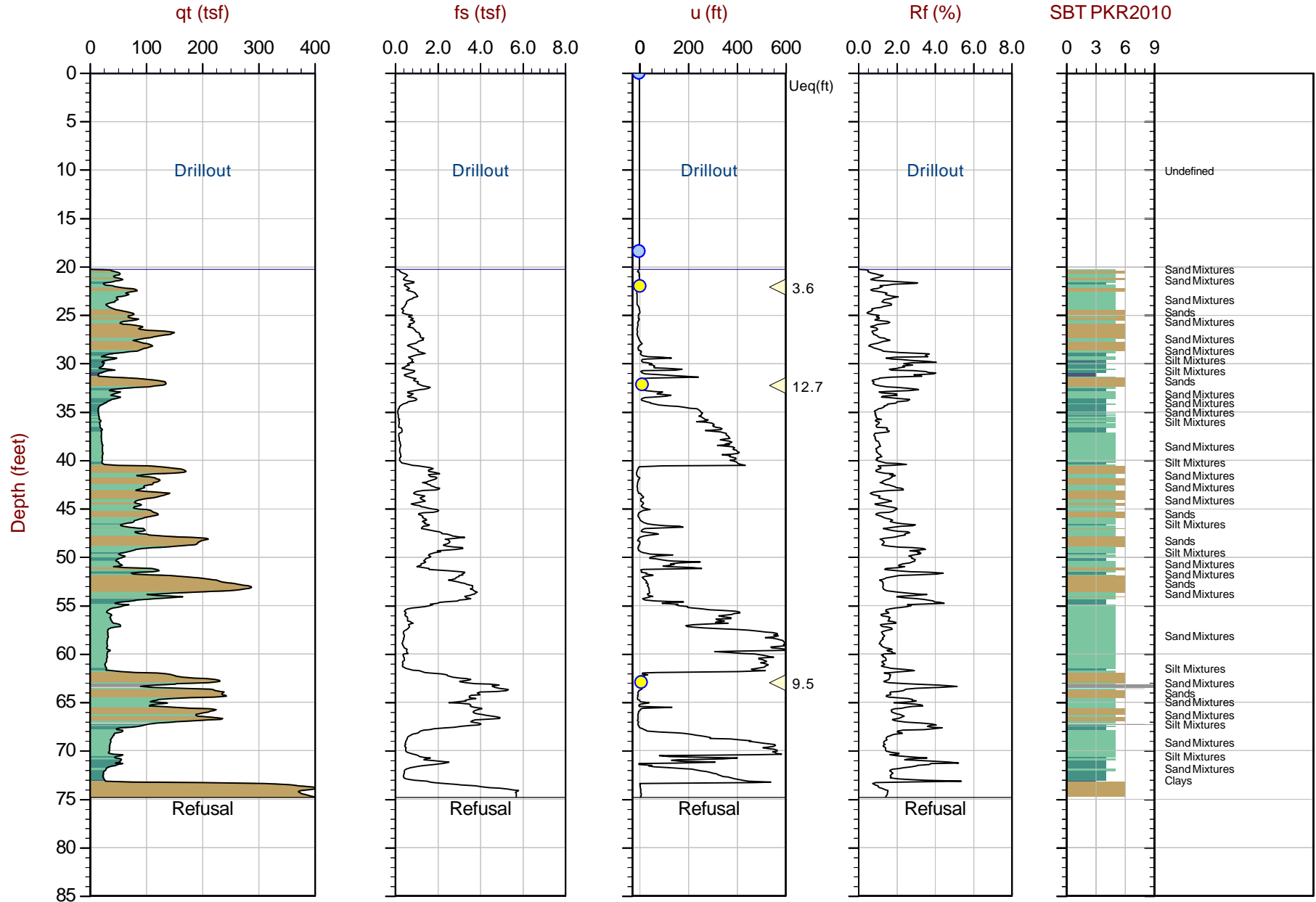
2. Elevations are referenced to the ground surface at the time of testing and were derived from the Google Earth elevation.



AECOM

Job No: 22-52-24382
Date: 2022-07-29 08:46
Site: Provo WTP

Sounding: CP22-WTP-02
Cone: 691:T1500F15U35



Max Depth: 22.800 m / 74.80 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 22-52-24382_CP02.COR

SBT: Robertson, 2010 (CPT'10)
Coords: Lat: 40.261700 Long: -111.661759
Sheet No: 1 of 1

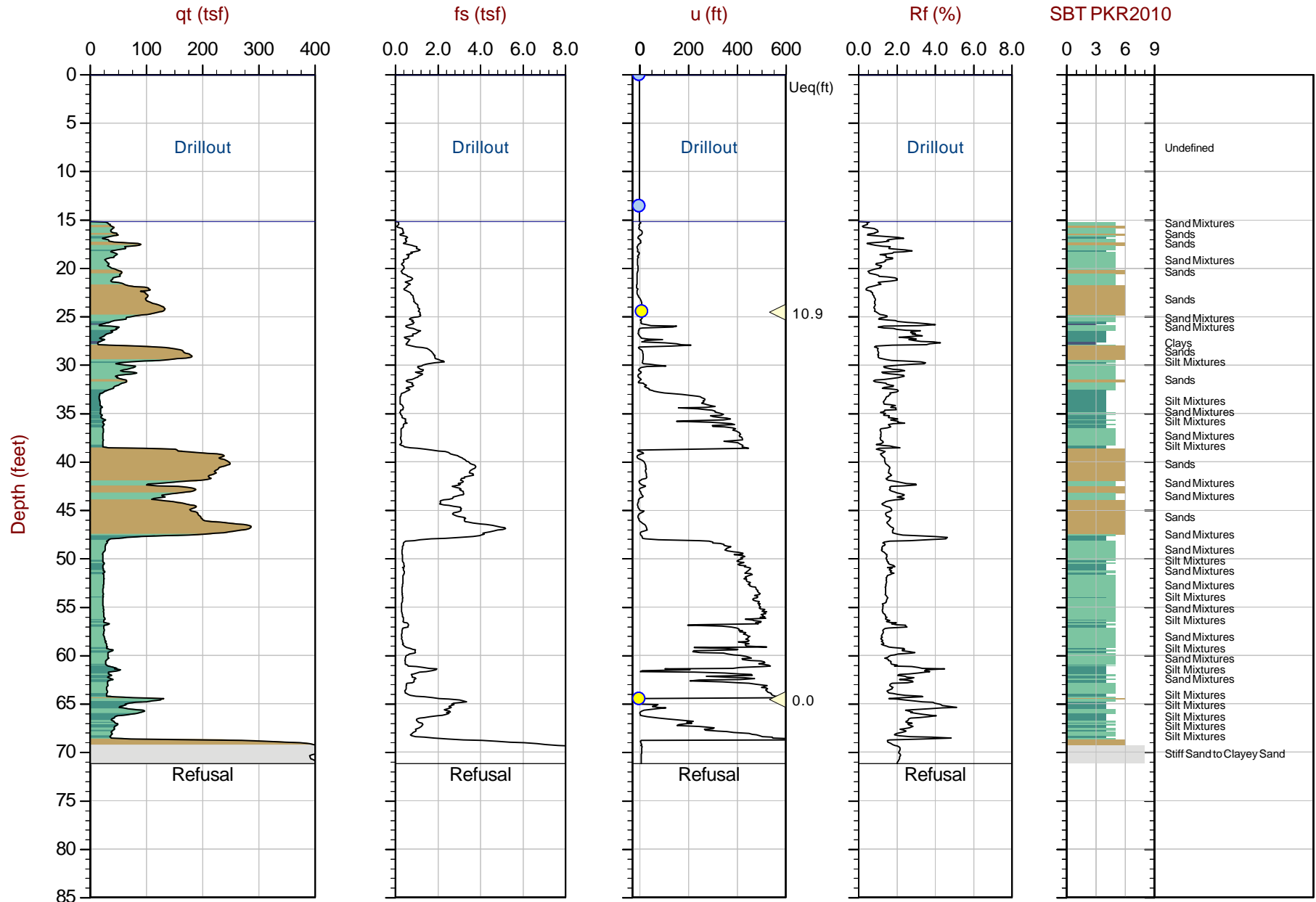
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved — Hydrostatic Line
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.



AECOM

Job No: 22-52-24382
Date: 2022-07-29 11:25
Site: Provo WTP

Sounding: CP22-WTP-04
Cone: 691:T1500F15U35

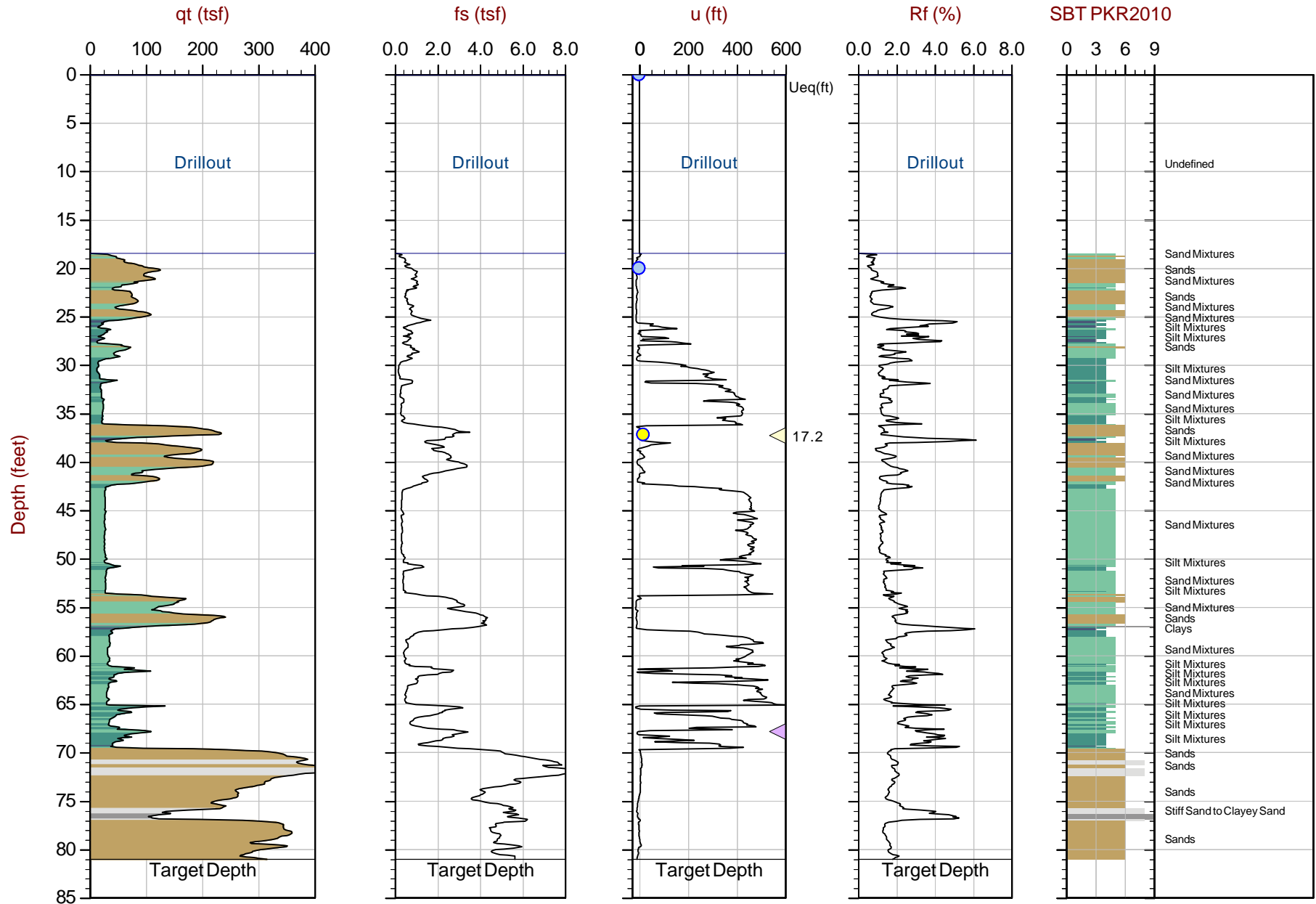


Max Depth: 21.700 m / 71.19 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 22-52-24382_CP04.COR

SBT: Robertson, 2010 (CPT'10)
Coords: Lat: 40.261882 Long: -111.662290
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved — Hydrostatic Line
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.



Max Depth: 24.700 m / 81.04 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 22-52-24382_CP05.COR

SBT: [Robertson, 2010 \(CPT '10\)](#)
 Coords: [Lat: 40.262208](#) [Long: -111.662280](#)
 Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq)
 ● Assumed Ueq
 ◀ Dissipation, Ueq achieved
 ◀ Dissipation, Ueq not achieved
 — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots



Job No: 22-52-24382
Client: AECOM
Project: Provo WTP
Start Date: 29-Jul-2022
End Date: 29-Jul-2022

CPT_u PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm ²)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U _{eq} (ft)	Calculated Phreatic Surface (ft)	Refer to Notation Number
CP22-WTP-02	22-52-24382_CP02	15	500	22.06	3.6	18.5	
CP22-WTP-02	22-52-24382_CP02	15	500	32.23	12.7	19.5	
CP22-WTP-02	22-52-24382_CP02	15	500	62.99	9.5	53.4	
CP22-WTP-04	22-52-24382_CP04	15	500	24.52	10.9	13.6	
CP22-WTP-04	22-52-24382_CP04	15	600	64.55	0.0		
CP22-WTP-05	22-52-24382_CP05	15	600	37.24	17.2	20.1	
CP22-WTP-05	22-52-24382_CP05	15	900	67.83	N/A		1

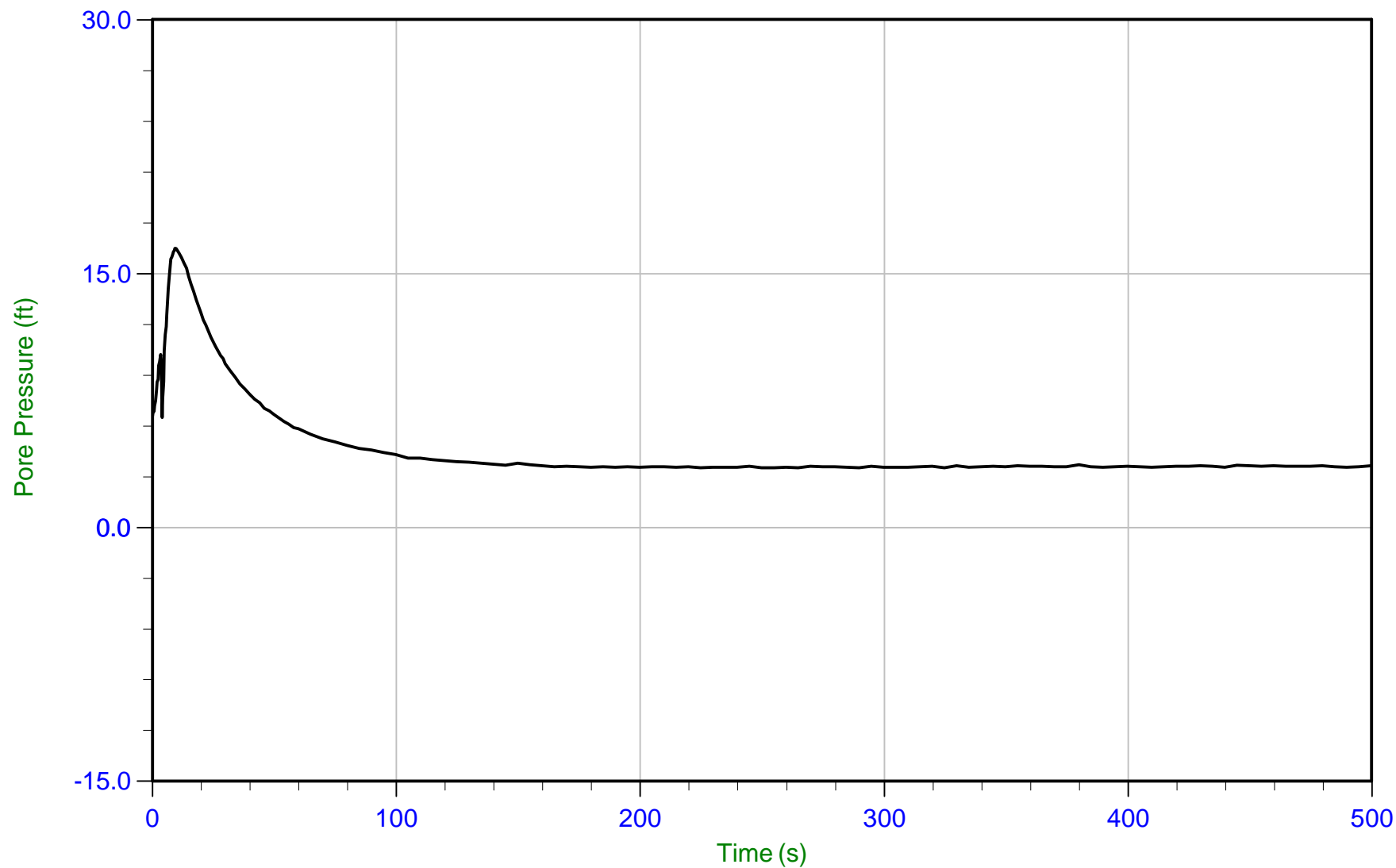
1. Pore pressure dissipation test ended by the client.



AECOM

Job No: 22-52-24382
Date: 07/29/2022 09:05
Site: Provo WTP

Sounding: CP22-WTP-02
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP02.PPR2
Depth: 6.725 m / 22.063 ft
Duration: 500.0 s

u Min: 3.5 ft
u Max: 16.5 ft
u Final: 3.6 ft

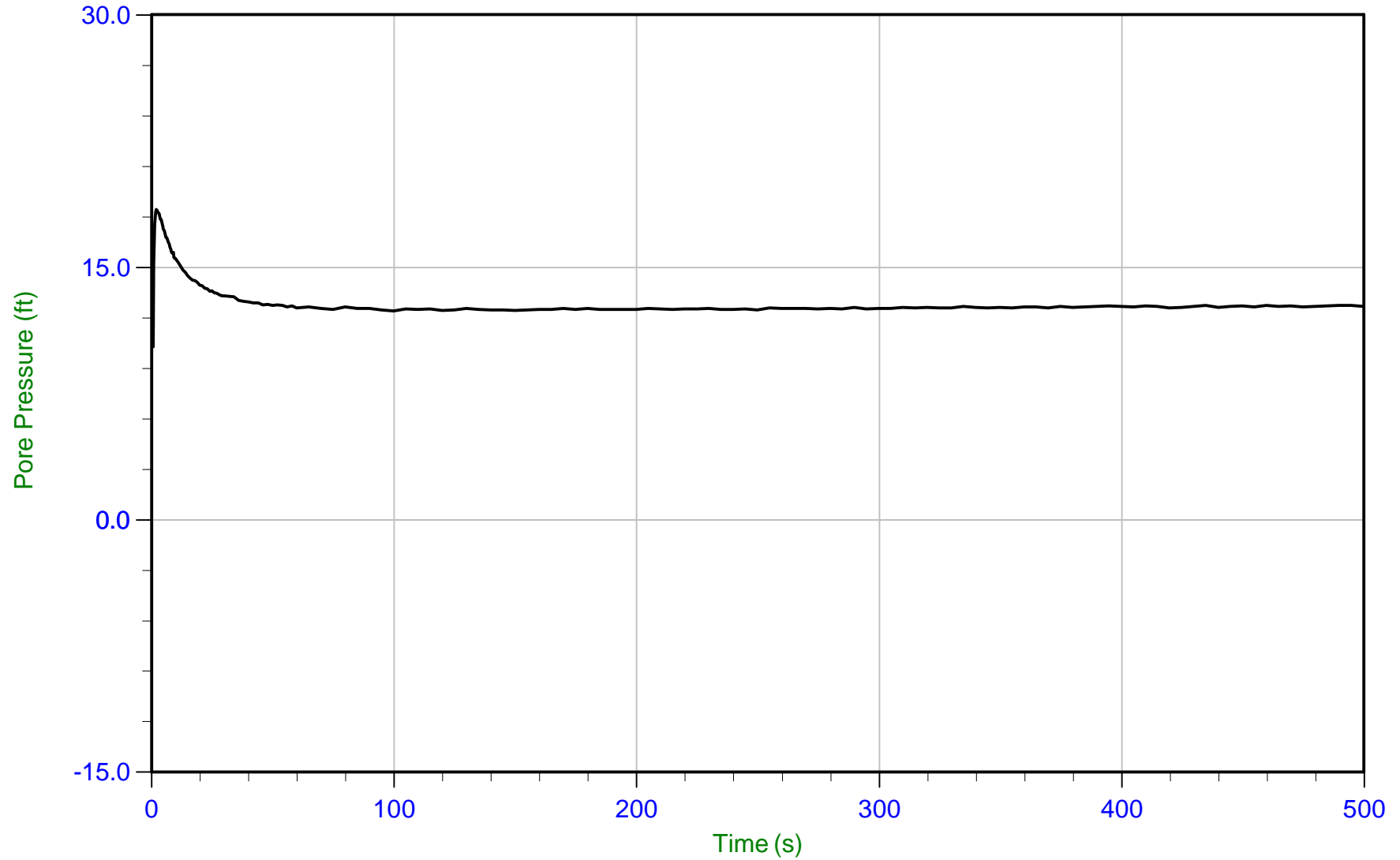
WT: 5.627 m / 18.463 ft
Ueq: 3.6 ft



AECOM

Job No: 22-52-24382
Date: 07/29/2022 09:05
Site: Provo WTP

Sounding: CP22-WTP-02
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP02.PPR2
Depth: 9.825 m / 32.234 ft
Duration: 500.0 s

u Min: 10.3 ft
u Max: 18.4 ft
u Final: 12.7 ft

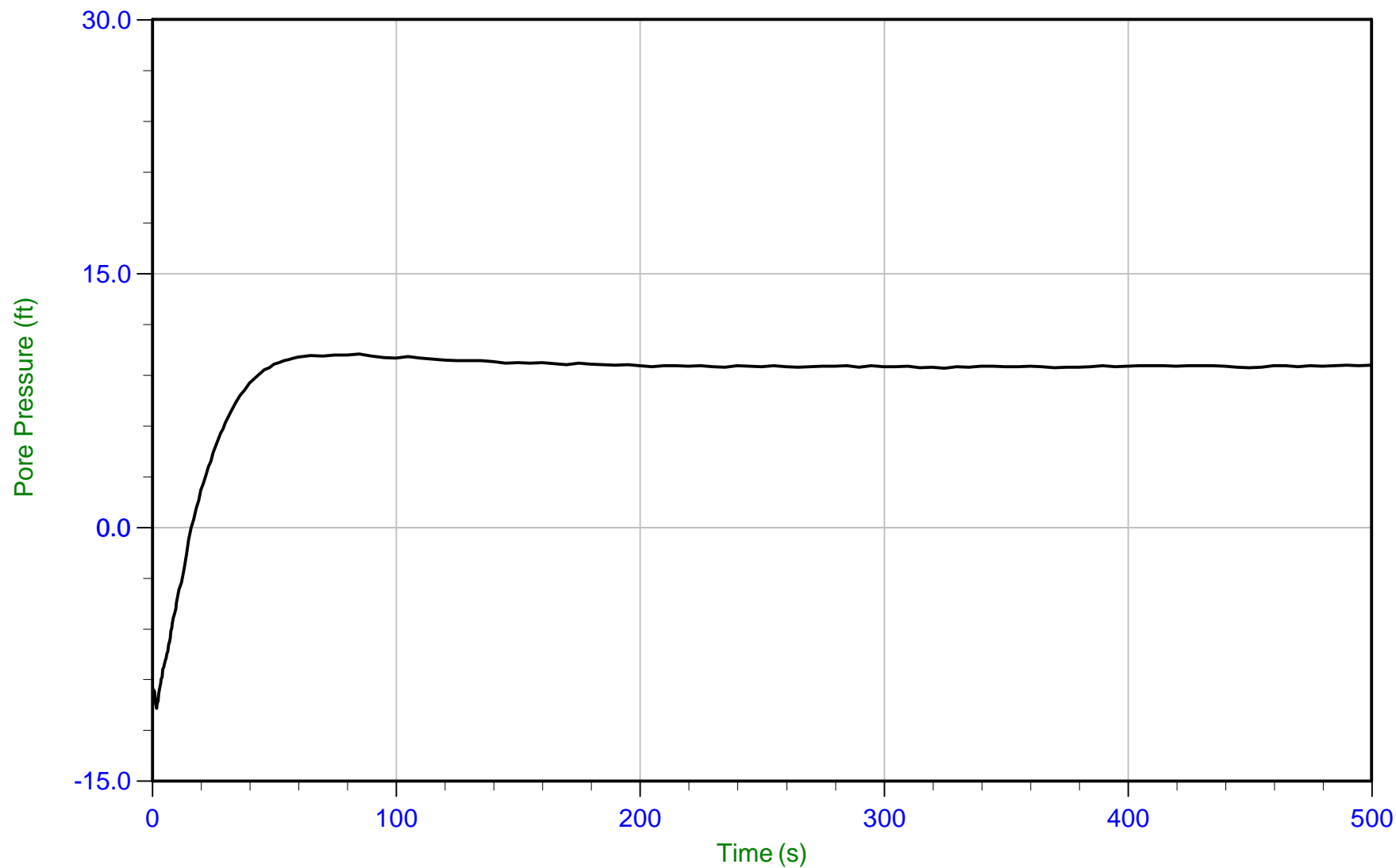
WT: 5.957 m / 19.544 ft
Ueq: 12.7 ft



AECOM

Job No: 22-52-24382
Date: 07/29/2022 09:05
Site: Provo WTP

Sounding: CP22-WTP-02
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP02.PPR2
Depth: 19.200 m / 62.991 ft
Duration: 500.0 s

u Min: -10.7 ft
u Max: 10.2 ft
u Final: 9.6 ft

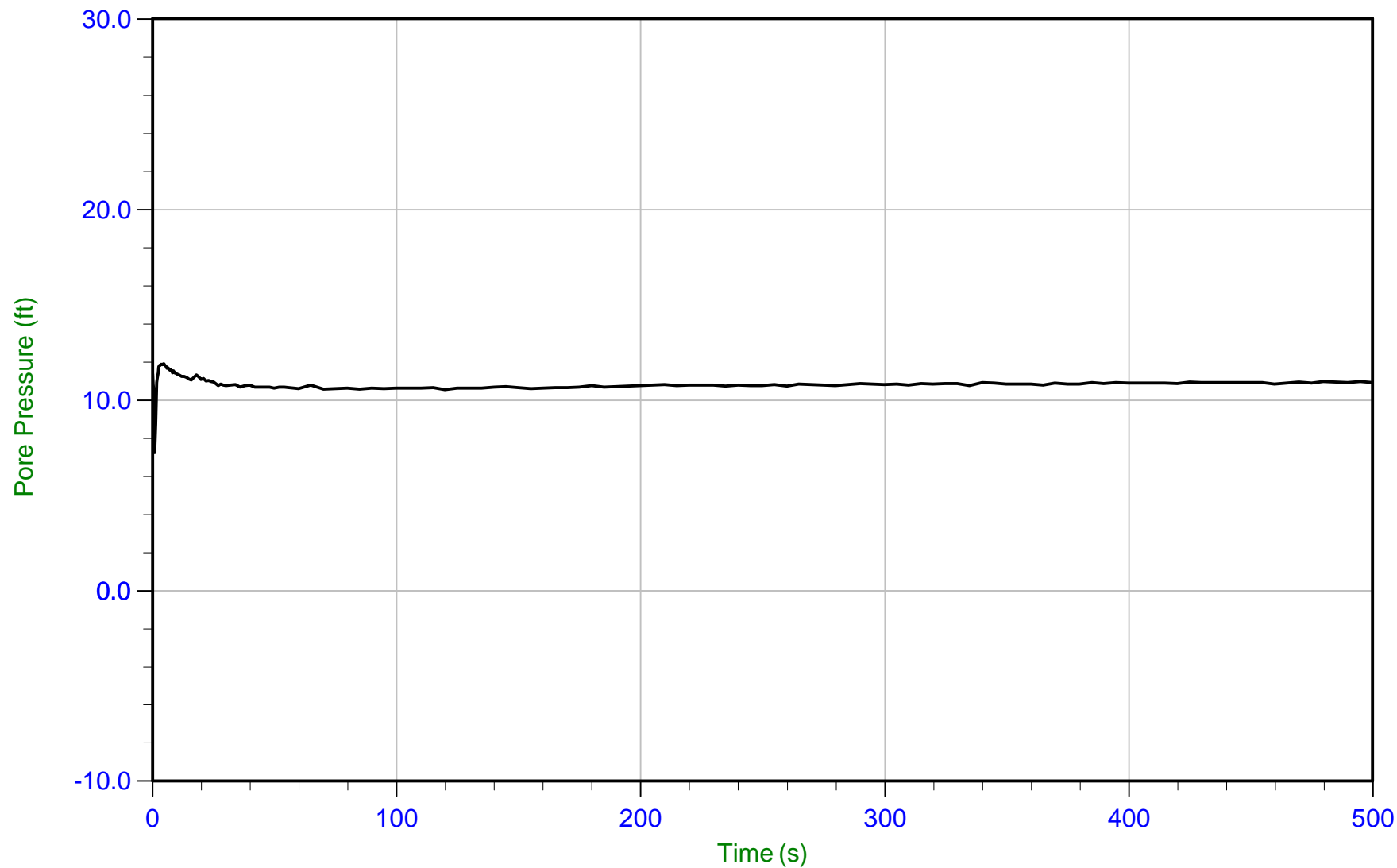
WT: 16.291 m / 53.448 ft
Ueq: 9.5 ft



AECOM

Job No: 22-52-24382
Date: 07/29/2022 11:44
Site: Provo WTP

Sounding: CP22-WTP-04
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP04.PPR2
Depth: 7.475 m / 24.524 ft
Duration: 500.0 s

u Min: 7.2 ft
u Max: 11.9 ft
u Final: 10.9 ft

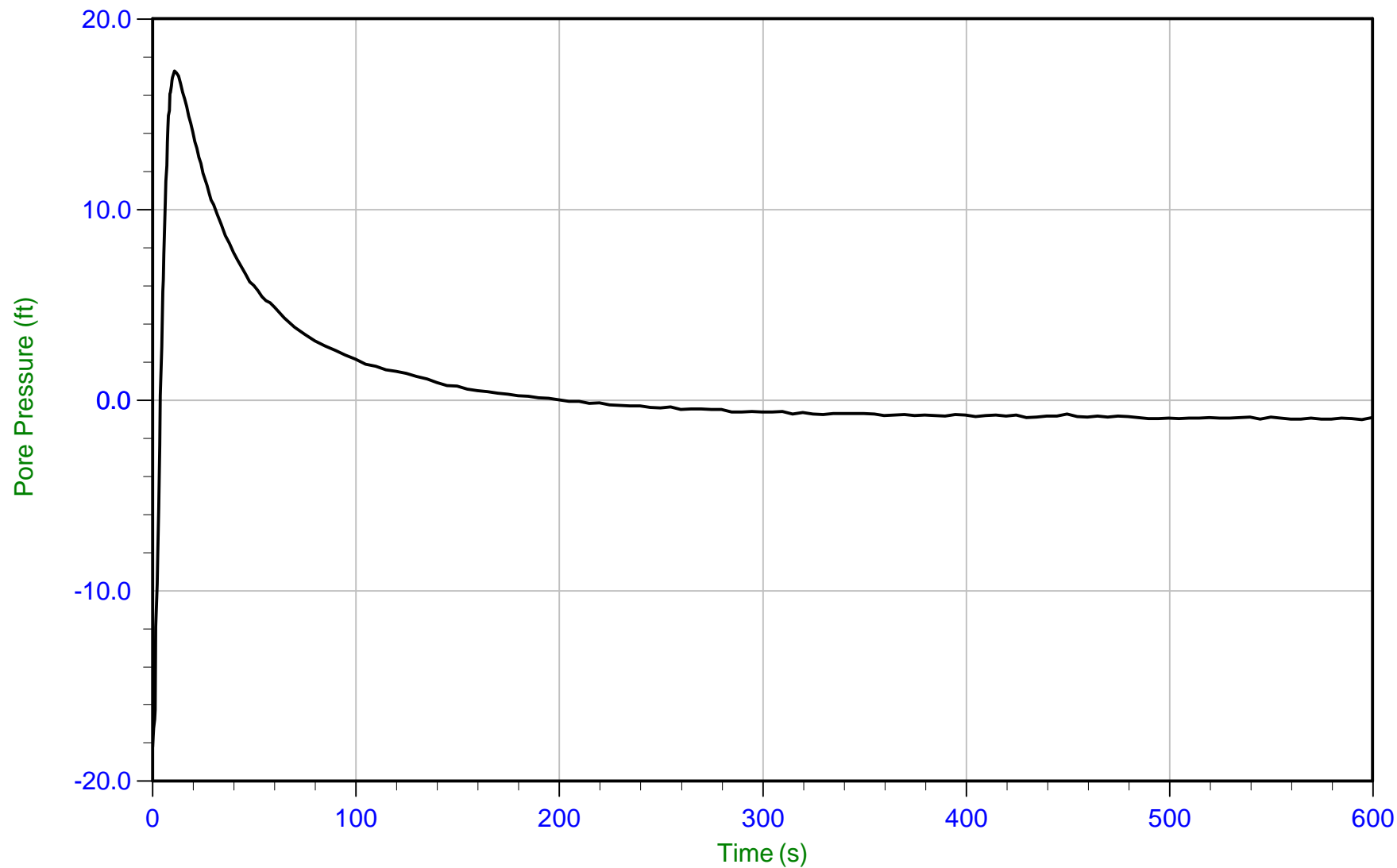
WT: 4.145 m / 13.598 ft
Ueq: 10.9 ft



AECOM

Job No: 22-52-24382
Date: 07/29/2022 11:44
Site: Provo WTP

Sounding: CP22-WTP-04
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP04.PPR2
Depth: 19.675 m / 64.550 ft
Duration: 600.0 s

u Min: -18.2 ft
u Max: 17.3 ft
u Final: -0.9 ft

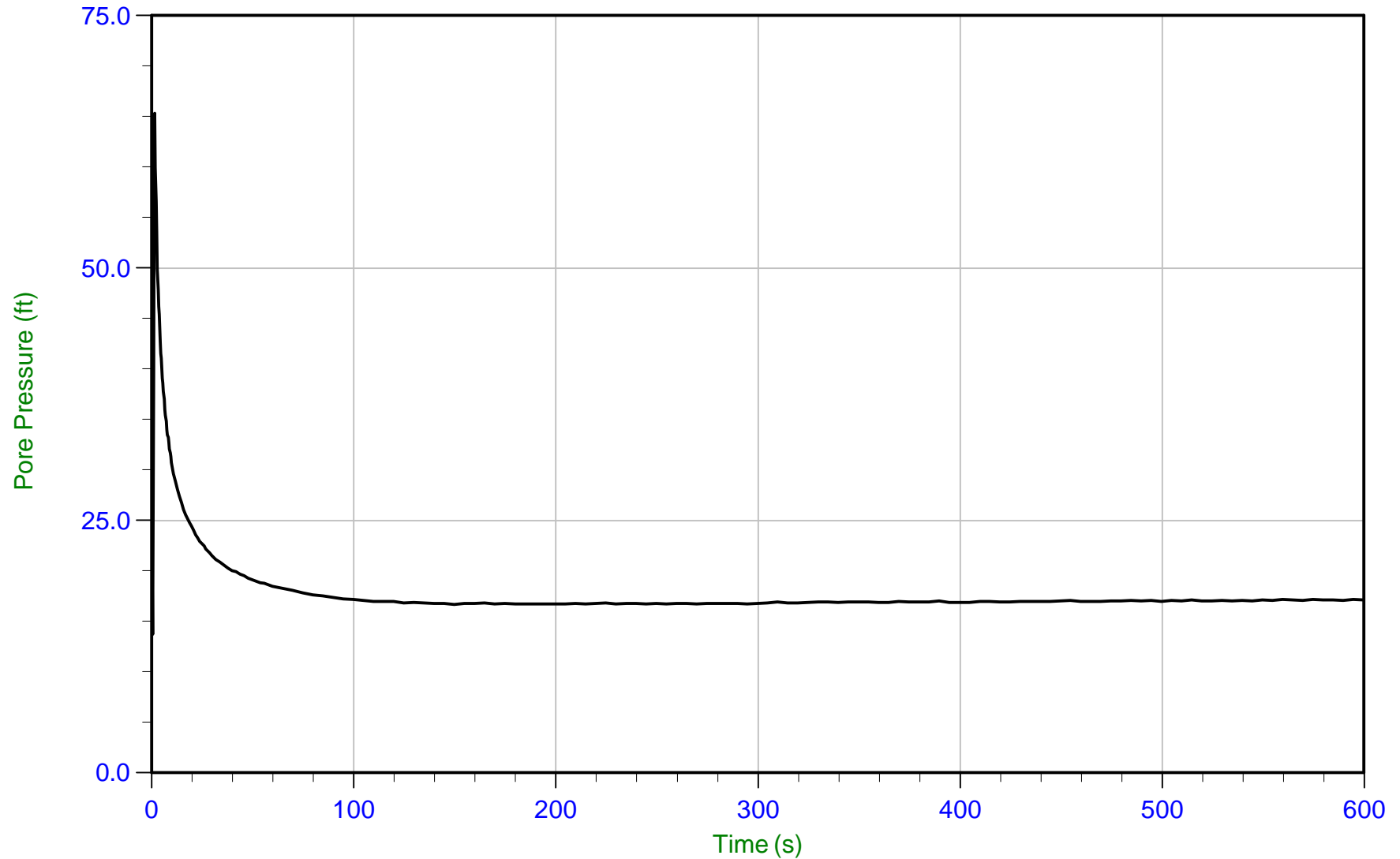
WT: 19.675 m / 64.550 ft
Ueq: 0.0 ft



AECOM

Job No: 22-52-24382
Date: 07/29/2022 13:58
Site: Provo WTP

Sounding: CP22-WTP-05
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP05.PPR2
Depth: 11.350 m / 37.237 ft
Duration: 600.0 s

u Min: 13.7 ft
u Max: 65.3 ft
u Final: 17.1 ft

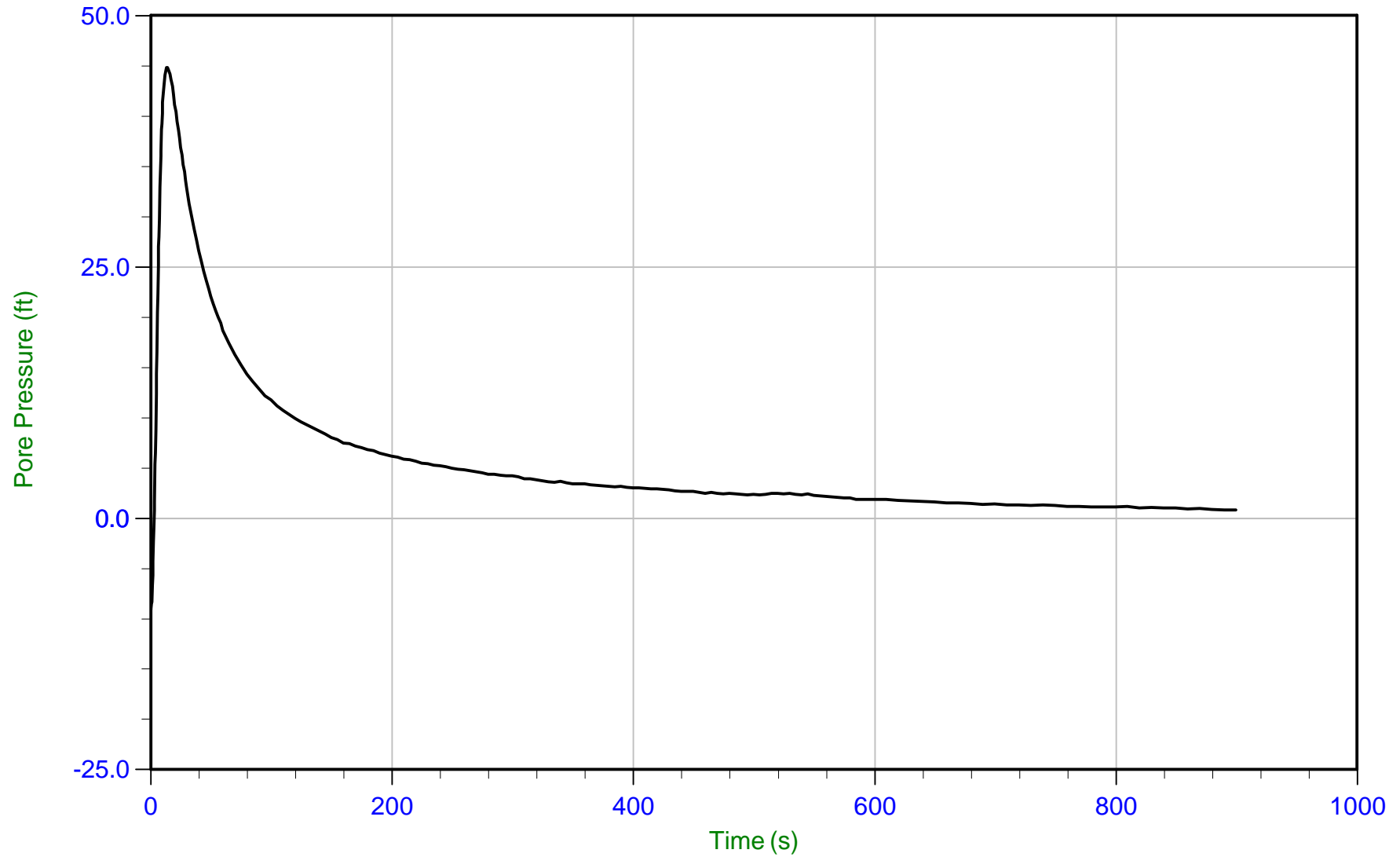
WT: 6.113 m / 20.057 ft
Ueq: 17.2 ft



AECOM

Job No: 22-52-24382
Date: 07/29/2022 13:58
Site: Provo WTP

Sounding: CP22-WTP-05
Cone: 691:T1500F15U35 Area=15 cm²



Trace Summary:

Filename: 22-52-24382_CP05.PPR2
Depth: 20.675 m / 67.831 ft
Duration: 900.0 s

u Min: -9.1 ft
u Max: 44.8 ft
u Final: 0.8 ft

Methodology Statements and Data File Formats

METHODOLOGY STATEMENTS



CONE PENETRATION TEST (CPTu) - eSeries

Cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd., a subsidiary of ConeTec.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and two geophone sensors for recording seismic signals. All signals are amplified and measured with minimum sixteen-bit resolution down hole within the cone body, and the signals are sent to the surface using a high bandwidth, error corrected digital interface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm² and 15 cm² tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table. The 15 cm² penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm² piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 millimeters diameter over a length of 32 millimeters with tapered leading and trailing edges) located at a distance of 585 millimeters above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u₂" position ([ASTM Type 2](#)). The filter is six millimeters thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current [ASTM D5778](#) standard. ConeTec's calibration criteria also meets or exceeds those of the current [ASTM D5778](#) standard. An illustration of the piezocone penetrometer is presented in [Figure CPTu](#).

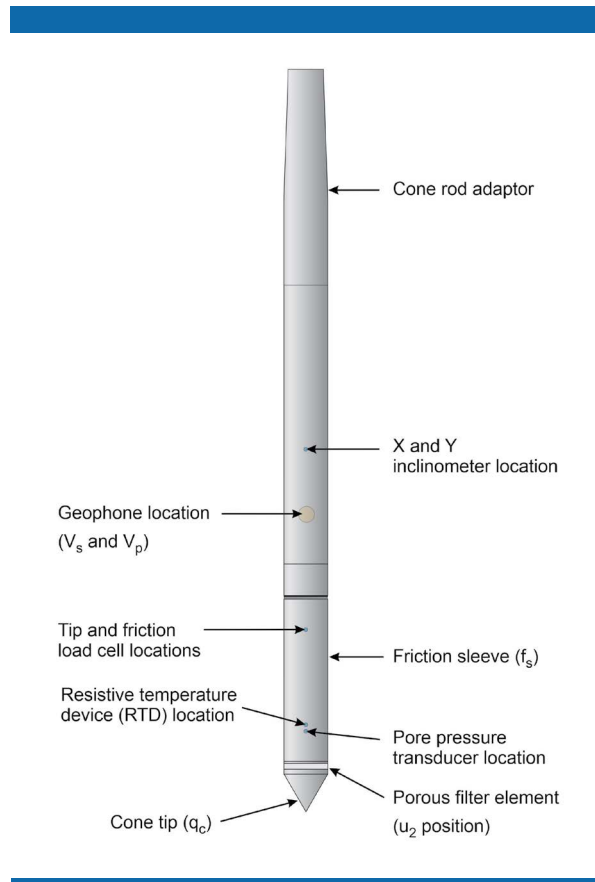


Figure CPTu. Piezocone Penetrometer (15 cm²)

The ConeTec data acquisition system consists of a Windows based computer, signal interface box, and power supply. The signal interface combines depth increment signals, seismic trigger signals and the downhole digital data. This combined data is then sent to the Windows based computer for collection and presentation. The data is recorded at fixed depth increments using a depth encoder that is either portable or integrated into the rig. The typical recording interval is 2.5 centimeters; custom recording intervals are possible.

The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPTu operating procedures which are in general accordance with the current [ASTM D5778](#) standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of two centimeters per second, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil under vacuum pressure prior to use
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with [ASTM](#) standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by [Robertson, P.K., 2010](#). The Soil Behavior Type (SBT) classification chart developed by [Robertson, P.K., 2010](#) is presented in [Figure SBT](#). It should be noted that it is not always possible to accurately identify a soil behavior type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behavior type.

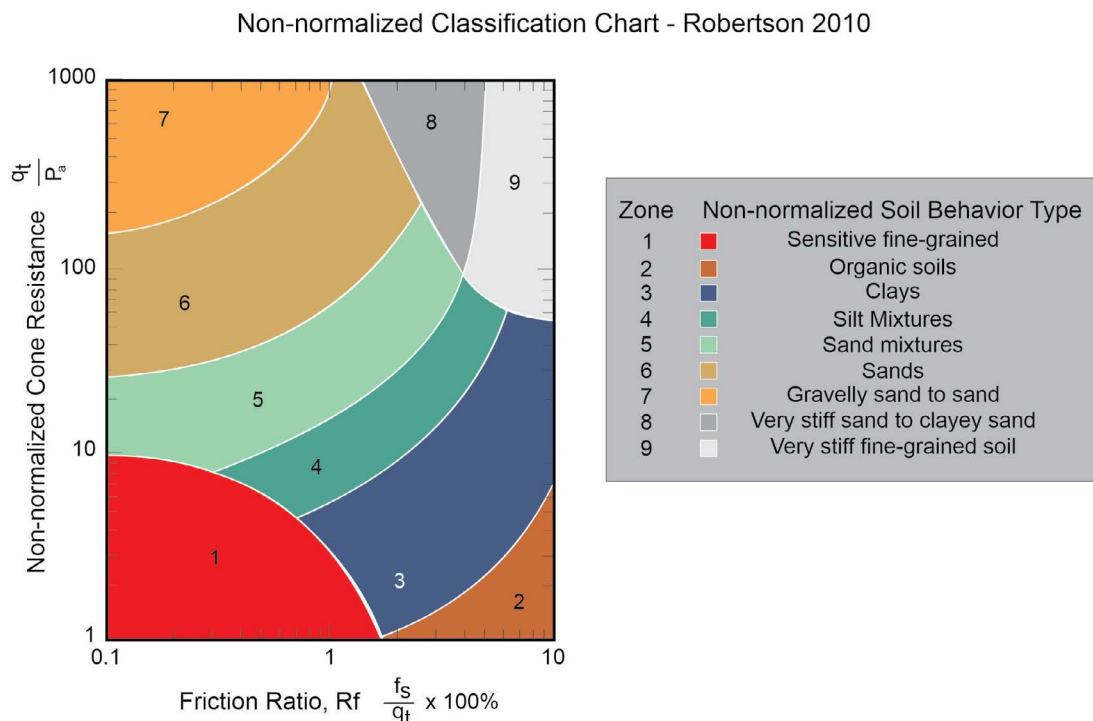


Figure SBT. Non-Normalized Soil Behavior Type Classification Chart (SBT)

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in [Robertson et al. \(1986\)](#):

$$q_t = q_c + (1-a) \cdot u_2$$

where: q_t is the corrected tip resistance

q_c is the recorded tip resistance

u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)

a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (R_f) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

For additional information on CPTu interpretations and calculated geotechnical parameters, refer to [Robertson et al. \(1986\)](#), [Lunne et al. \(1997\)](#), [Robertson \(2009\)](#), [Mayne \(2013, 2014\)](#) and [Mayne and Peuchen \(2012\)](#).

REFERENCES

ASTM D5778-20, 2020, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: [10.1520/D5778-20](#).

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, "Cone Penetration Testing in Geotechnical Practice", Blackie Academic and Professional.

Mayne, P.W., 2013, "Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests", Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420. DOI: [10.1061/9780784412770.027](#).

Mayne, P.W. and Peuchen, J., 2012, "Unit weight trends with cone resistance in soft to firm clays", Geotechnical and Geophysical Site Characterization 4, Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.

Mayne, P.W., 2014, "Interpretation of geotechnical parameters from seismic piezocone tests", CPT'14 Keynote Address, Las Vegas, NV, May 2014.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, "Use of Piezometer Cone Data", Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 2009, "Interpretation of cone penetration tests – a unified approach", Canadian Geotechnical Journal, Volume 46: 1337-1355. DOI: [10.1139/T09-065](#).

Robertson, P.K., 2010. Soil behavior type from the CPT: an update. 2nd International Symposium on Cone Penetration Testing, CPT'10, Huntington Beach, CA, USA



PORE PRESSURE DISSIPATION TEST

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in [Figure PPD-1](#). For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

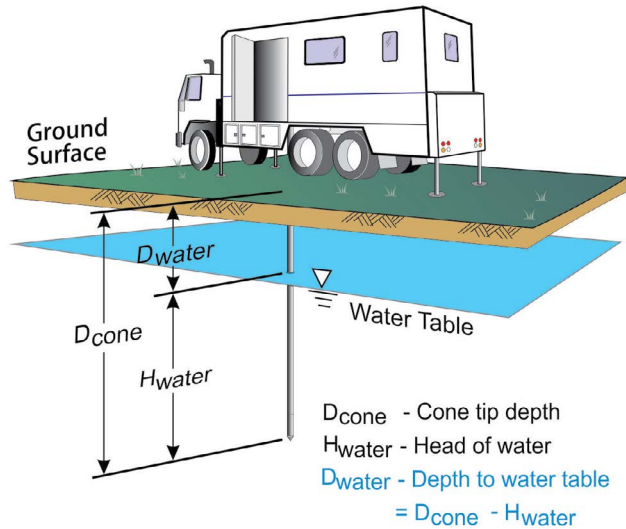


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behavior.

The typical shapes of dissipation curves shown in [Figure PPD-2](#) are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

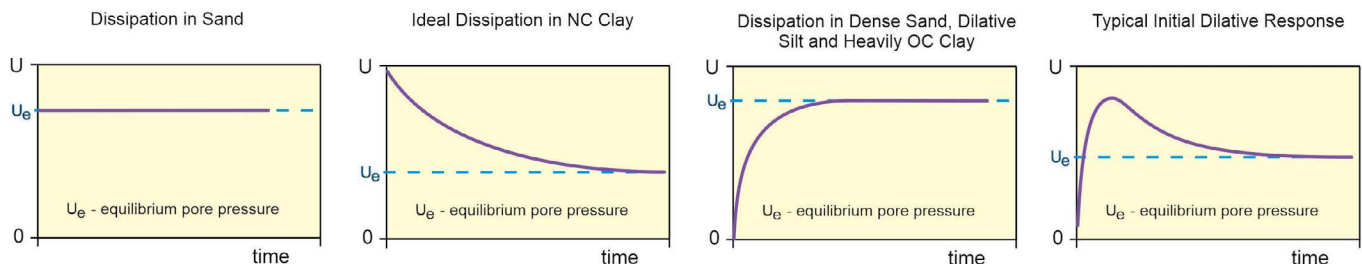


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve in [Figure PPD-2](#).



CONE PENETRATION DIGITAL FILE FORMATS - eSeries

CPT Data Files (COR Extension)

ConeTec CPT data files are stored in ASCII text files that are readable by almost any text editor. ConeTec file names start with the job number (which includes the two digit year number) an underscore as a separating character, followed by two letters based on the type of test and the sounding ID. The last character position is reserved for an identifier letter (such as b, c, d etc) used to uniquely distinguish multiple soundings at the same location. The CPT sounding file has the extension COR. As an example, for job number 21-02-00001 the first CPT sounding will have file name 21-02-00001_CP01.COR

The sounding (COR) file consists of the following components:

1. Two lines of header information
2. Data records
3. End of data marker
4. Units information

Header Lines

Line 1: Columns 1-6 may be blank or may indicate the version number of the recording software

Columns 7-21 contain the sounding Date and Time (Date is MM:DD:YY)

Columns 23-38 contain the sounding Operator

Columns 51-100 contain extended Job Location information

Line 2: Columns 1-16 contain the Job Location

Columns 17-32 contain the Cone ID

Columns 33-47 contain the sounding number

Columns 51-100 may contain extended sounding ID information

Data Records

The data records contain 4 or more columns of data in floating point format. A comma and spaces separate each data item:

Column 1: Sounding Depth (meters)

Column 2: Tip (q_c), recorded in units selected by the operator

Column 3: Sleeve (f_s), recorded in units selected by the operator

Column 4: Dynamic pore pressure (u), recorded in units selected by the operator

Column 5: Empty or may contain other requested data such as Gamma, Resistivity or UVIF data

End of Data Marker

After the last line of data there is a line containing an ASCII 26 (CTL-Z) character (small rectangular shaped character) followed by a newline (carriage return / line feed). This is used to mark the end of data.

Units Information

The last section of the file contains information about the units that were selected for the sounding. A separator bar makes up the first line. The second line contains the type of units used for depth, q_c , f_s and u . The third line contains the conversion values required for ConeTec's software to convert the recorded data to an internal set of base units (bar for q_c , bar for f_s and meters for u). Additional lines intended for internal ConeTec use may appear following the conversion values.

CPT Data Files (XLS Extension)

Excel format files of ConeTec CPT data are also generated from corresponding COR files. The XLS files have the same base file name as the COR file with a -BSC suffix. The information in the file is presented in table format and contains additional information about the sounding such as coordinate information, and tip net area ratio.

The BSCI suffix is given to XLS files which are enhanced versions of the BSC files and include the same data records in addition to inclination data collected for each sounding.

CPT Dissipation Files (XLS Extension)

Pore pressure dissipation files are provided in Excel format and contain each dissipation trace that exceeds a minimum duration (selected during post-processing) formatted column wise within the spreadsheet. The first column (Column A) contains the time in seconds and the second column (Column B) contains the time in minutes. Subsequent columns contain the dissipation trace data. The columns extend to the longest trace of the data set.

Detailed header information is provided at the top of the worksheet. The test depth in meters and feet, the number of points in the trace and the particular units are all presented at the top of each trace column.

CPT Dissipation files have the same naming convention as the CPT sounding files with a "-PPD" suffix.

Data Records

Each file will contain dissipation traces that exceed a minimum duration (selected during post-processing) in a particular column. The dissipation pore pressure values are typically recorded at varying time intervals throughout the trace; rapidly to start and increasing as the duration of the test lengthens. The test depth in meters and feet, the number of points in the trace and the trace number are identified at the top of each trace column.

Cone Type Designations

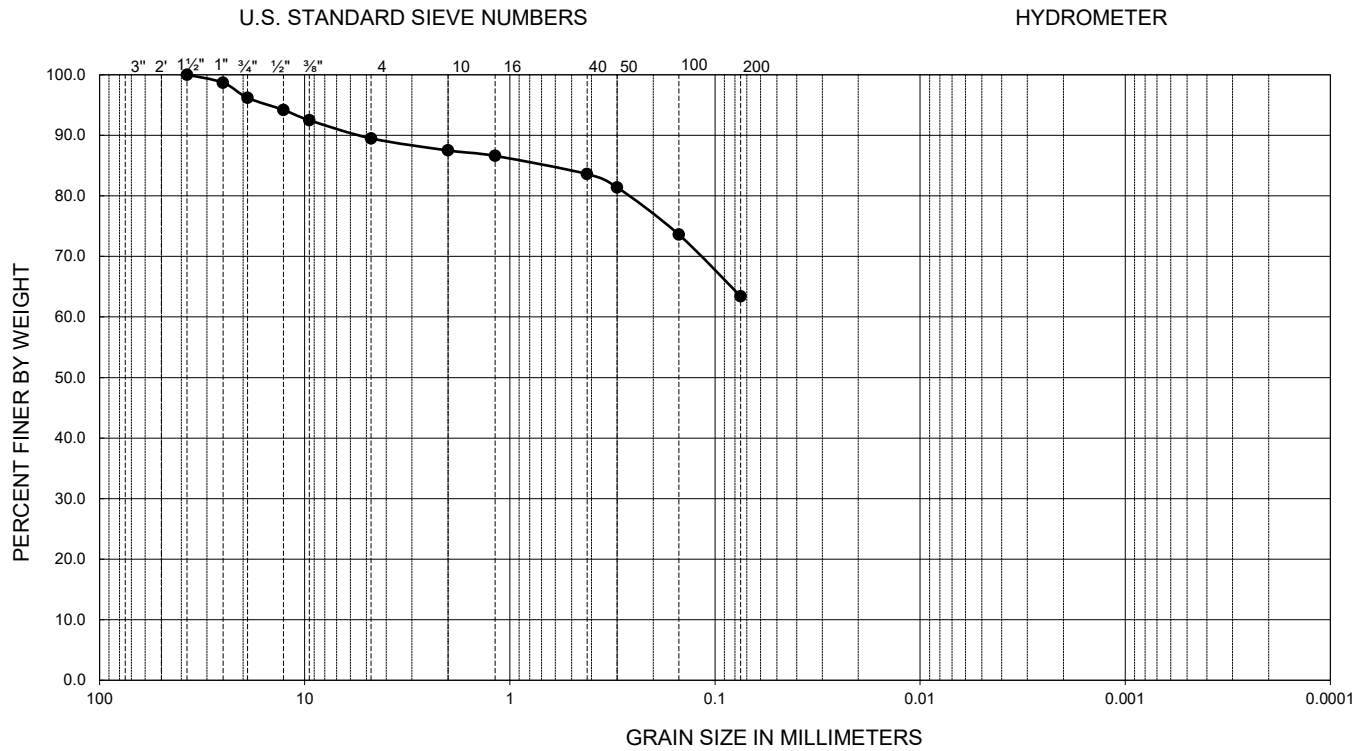
Cone ID	Cone Description	Tip Cross Sect. Area (cm ²)	Tip Capacity (bar)	Sleeve Area (cm ²)**	Sleeve Capacity (bar)	Pore Pressure Capacity (bar)
EC###	A15T1500F15U35	15	1500	225	15	35
EC###	A15T375F10U35	15	375	225	10	35
EC###	A10T1000F10U35	10	1000	150	10	35

refers to the Cone ID number

**Outer Cylindrical Area

Appendix D Laboratory Test Results

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-01 / BK-01	3.0-5.0	24	17	7	--	--	--	--	--	63.4	CL-ML

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Sandy silty CLAY
10.5	26.1	63.4	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			15.9%

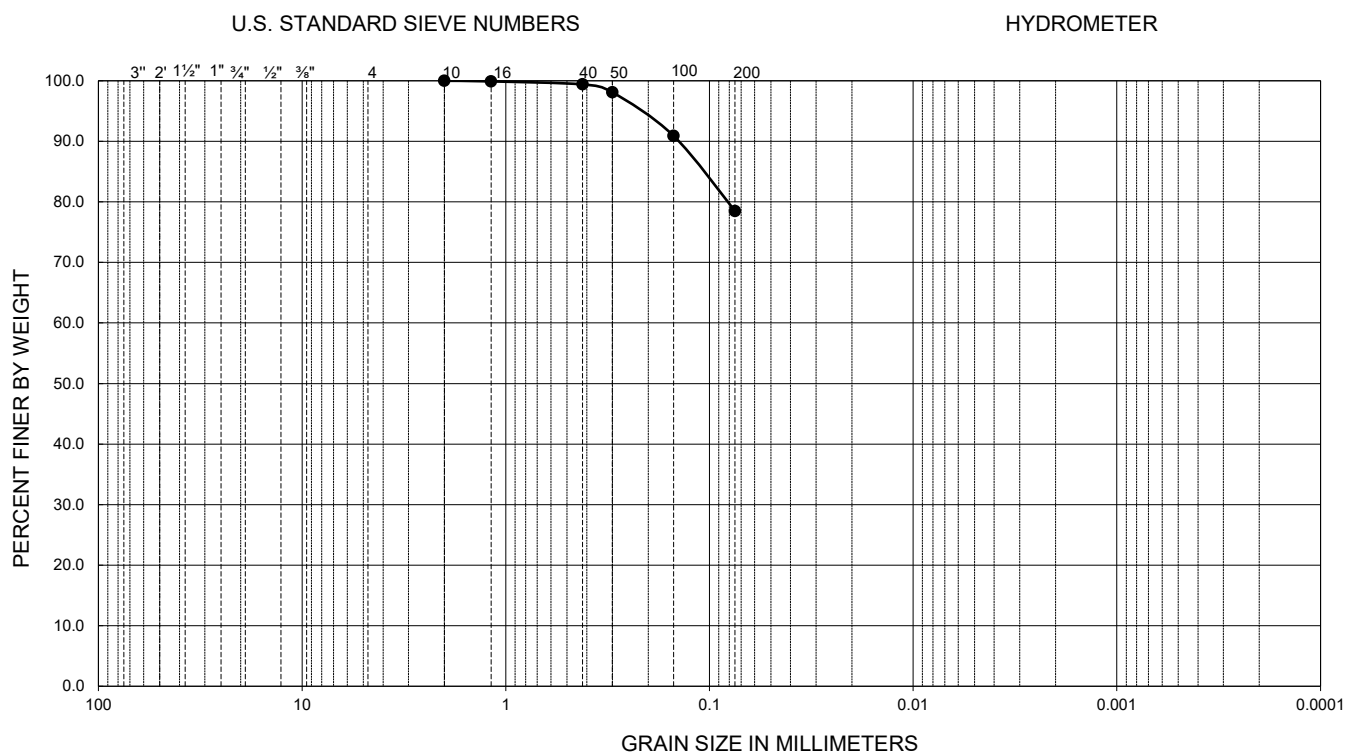
FIGURE B-1

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-01 / B-03	8.5-9.0	23	18	5	--	--	--	--	--	78.5	CL-ML

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty CLAY with sand
0.0	21.5	78.5	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			54.9%

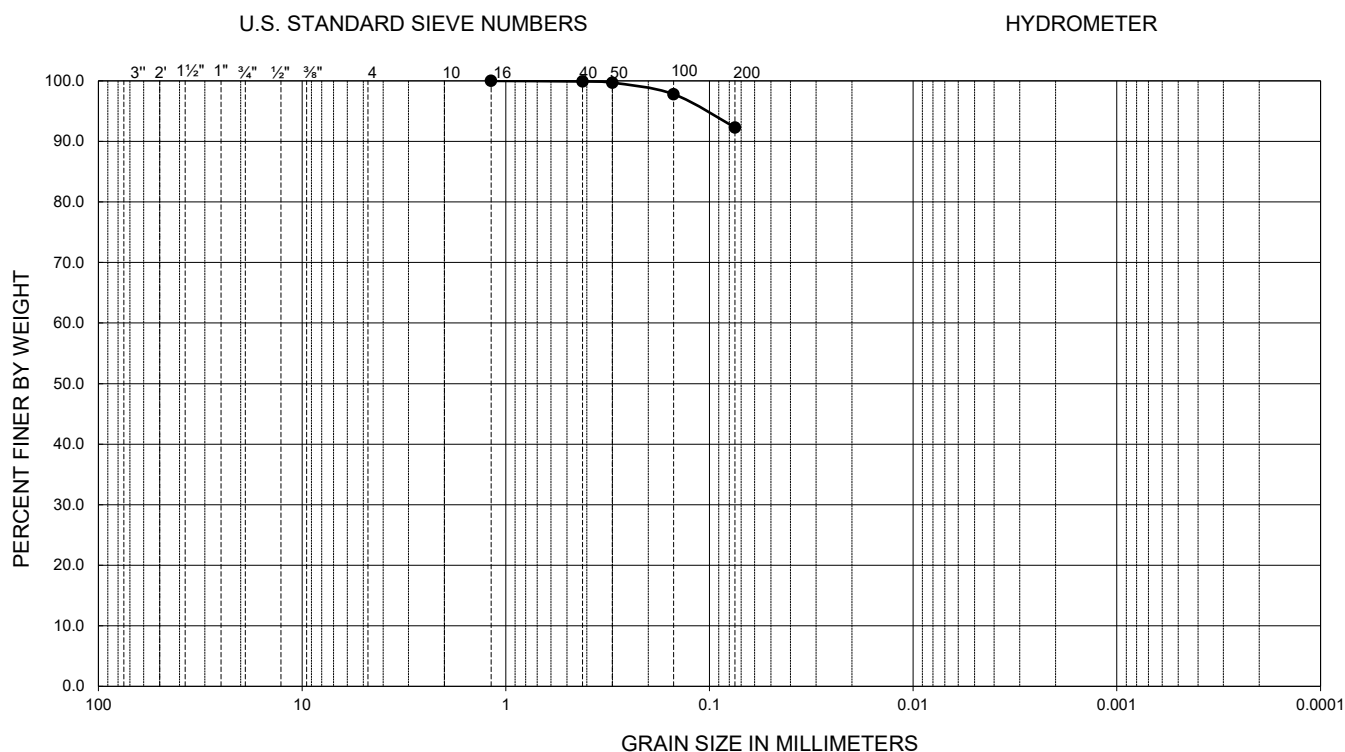
FIGURE B-2

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-02 / BK-02	3.0-6.0	29	19	10	--	--	--	--	--	92.3	CL

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Lean CLAY
0.0	7.7	92.3	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			19.7%

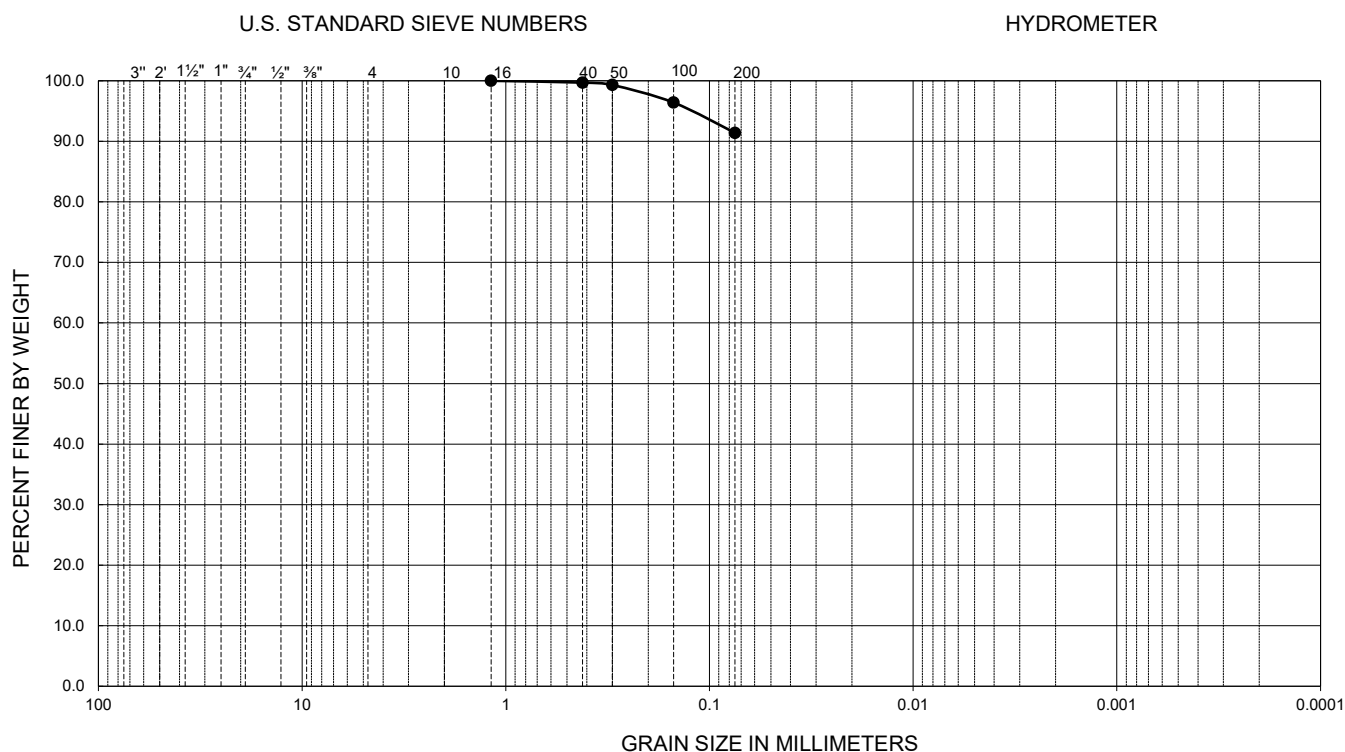
FIGURE B-3

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-02 / B-04	10.0-11.0	27	20	7	--	--	--	--	--	91.4	CL-ML

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty CLAY
0.0	8.6	91.4	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			22.2%

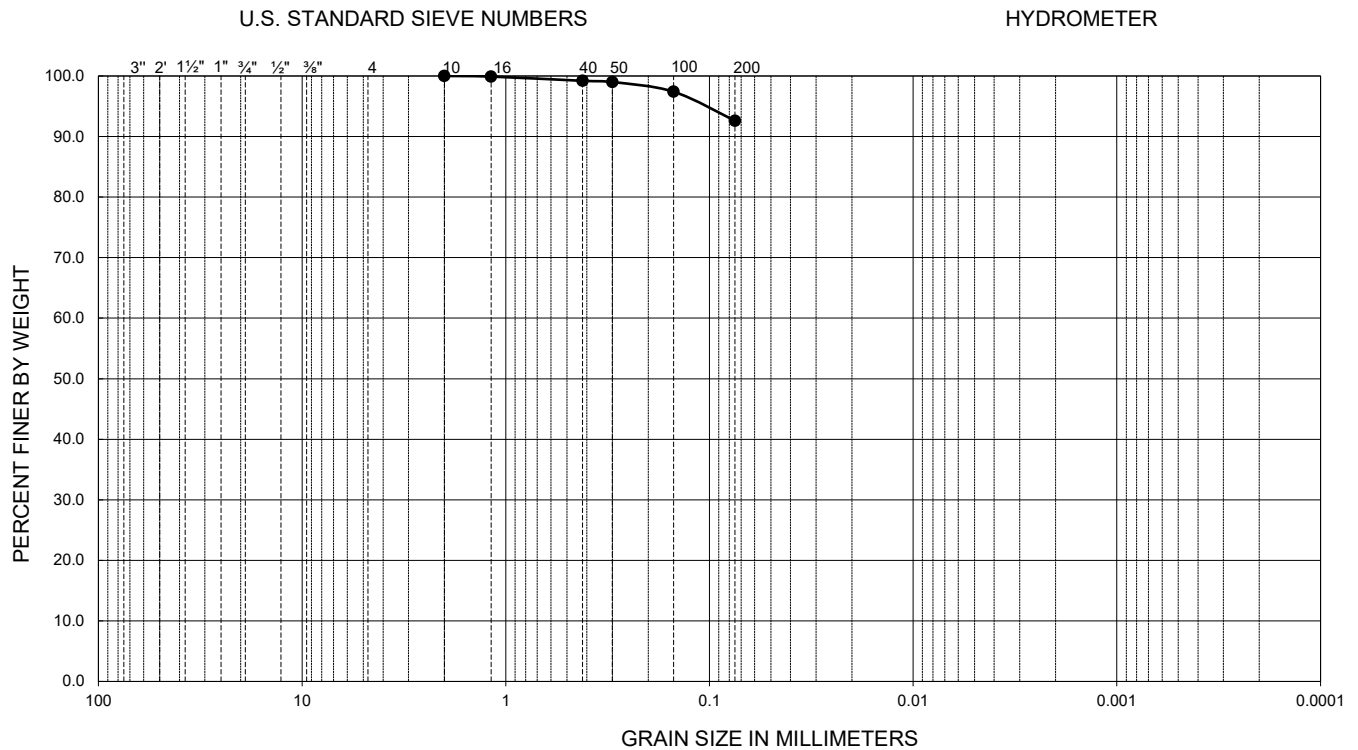
FIGURE B-4

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-02 / B-06	14.0-15.0	30	19	11	--	--	--	--	--	92.6	CL

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	Lean CLAY	
0.0	7.4	92.6		
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content	
			21.8%	

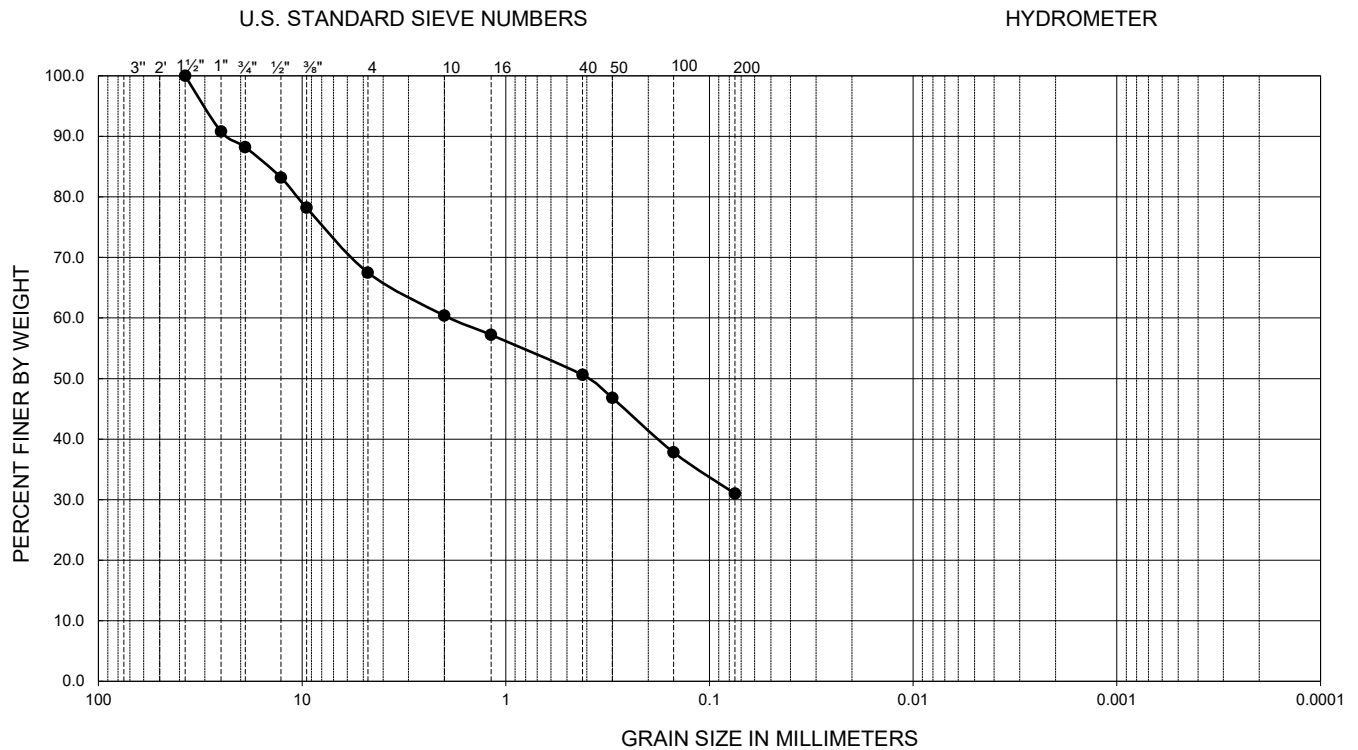
FIGURE B-5

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-03 / B-01	4.0-6.0	32	25	7	--	--	1.87	--	--	31.0	SM

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty SAND with gravel
32.5	36.5	31.0	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			36.9%

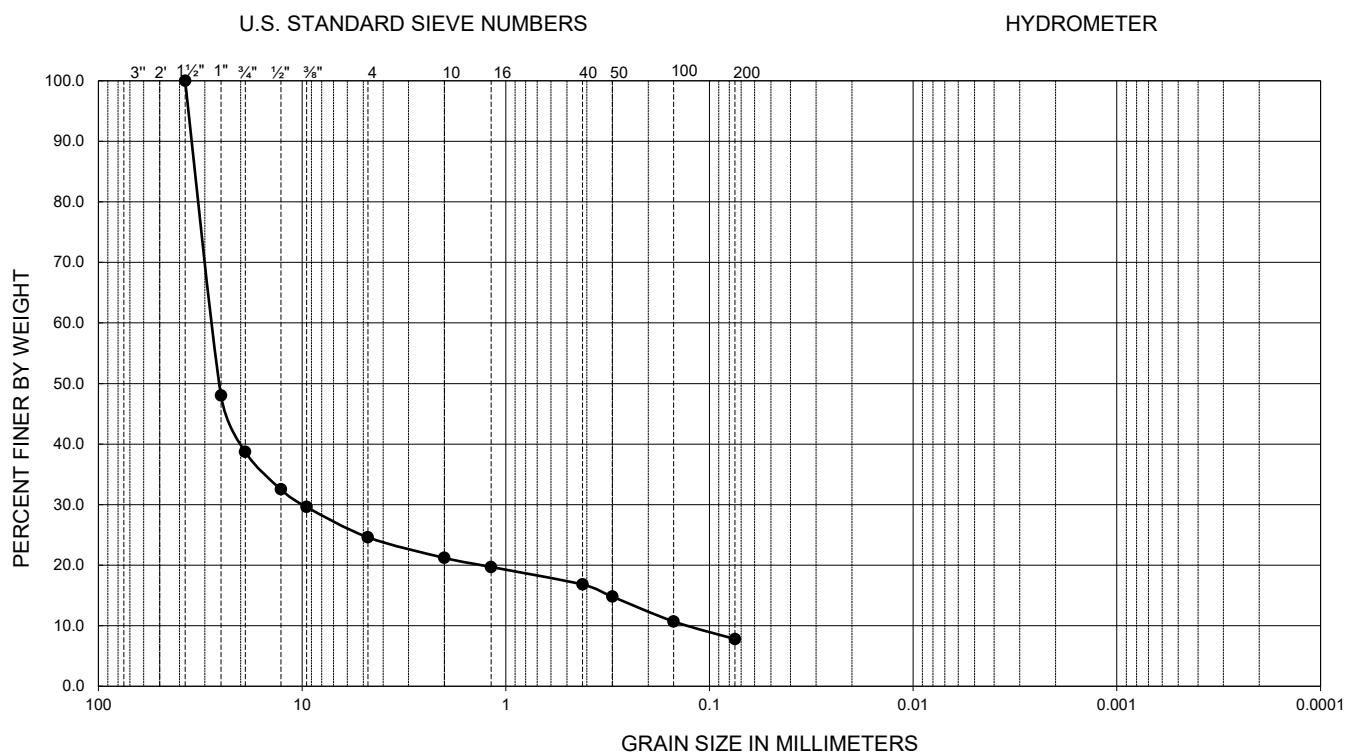
FIGURE B-6

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-P-03 / B-05	14.0-16.0	--	--	--	0.13	9.89	49.10	386.9	15.7	7.8	GP-GM

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Poorly graded GRAVEL with silt and sand
75.4	16.8	7.8	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			4.0%

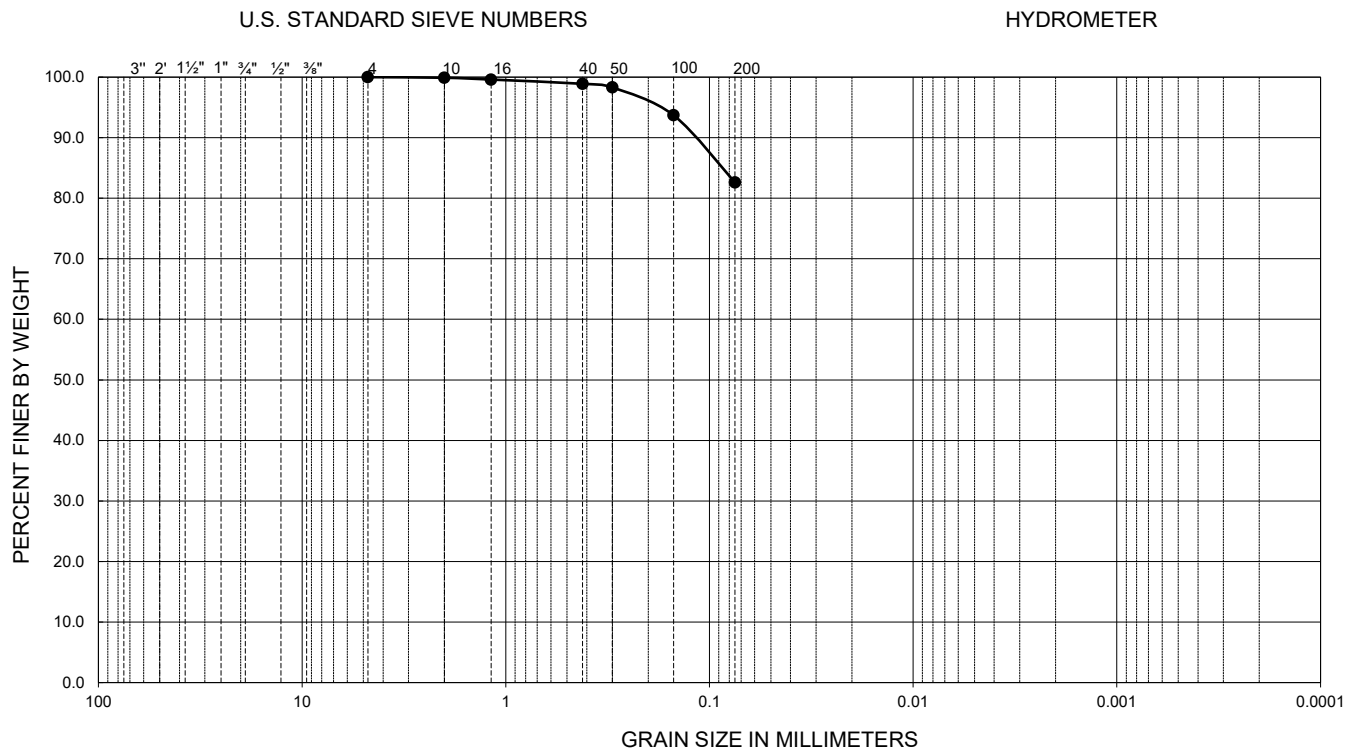
FIGURE B-7

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/2022

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-HDD-01 / SPT-04	6.5-8.0	23	18	5	--	--	--	--	--	82.6	CL-ML

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty CLAY with sand
0.0	17.4	82.6	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			14.0%

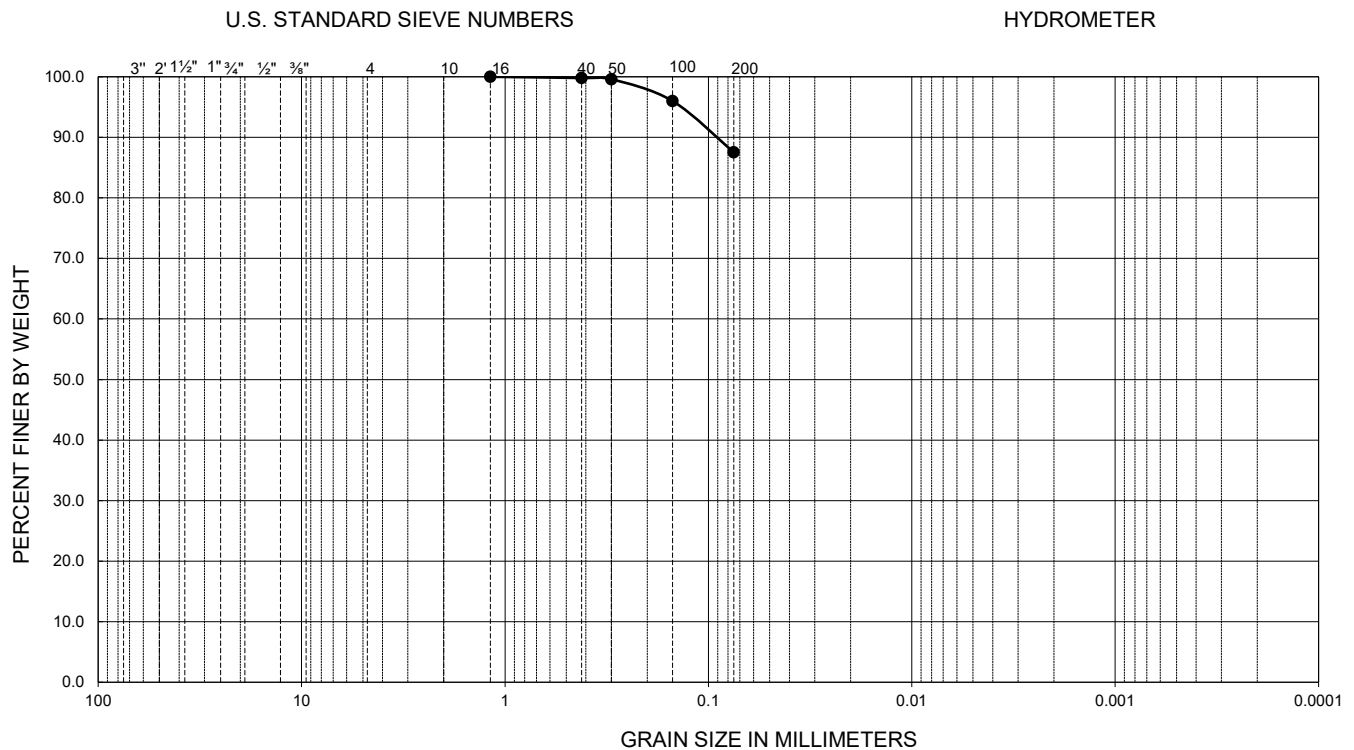
FIGURE B-8

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-HDD-01 / B-08	14.0-16.0	25	19	6	--	--	--	--	--	87.5	CL-ML

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty CLAY
0.0	12.5	87.5	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			17.4%

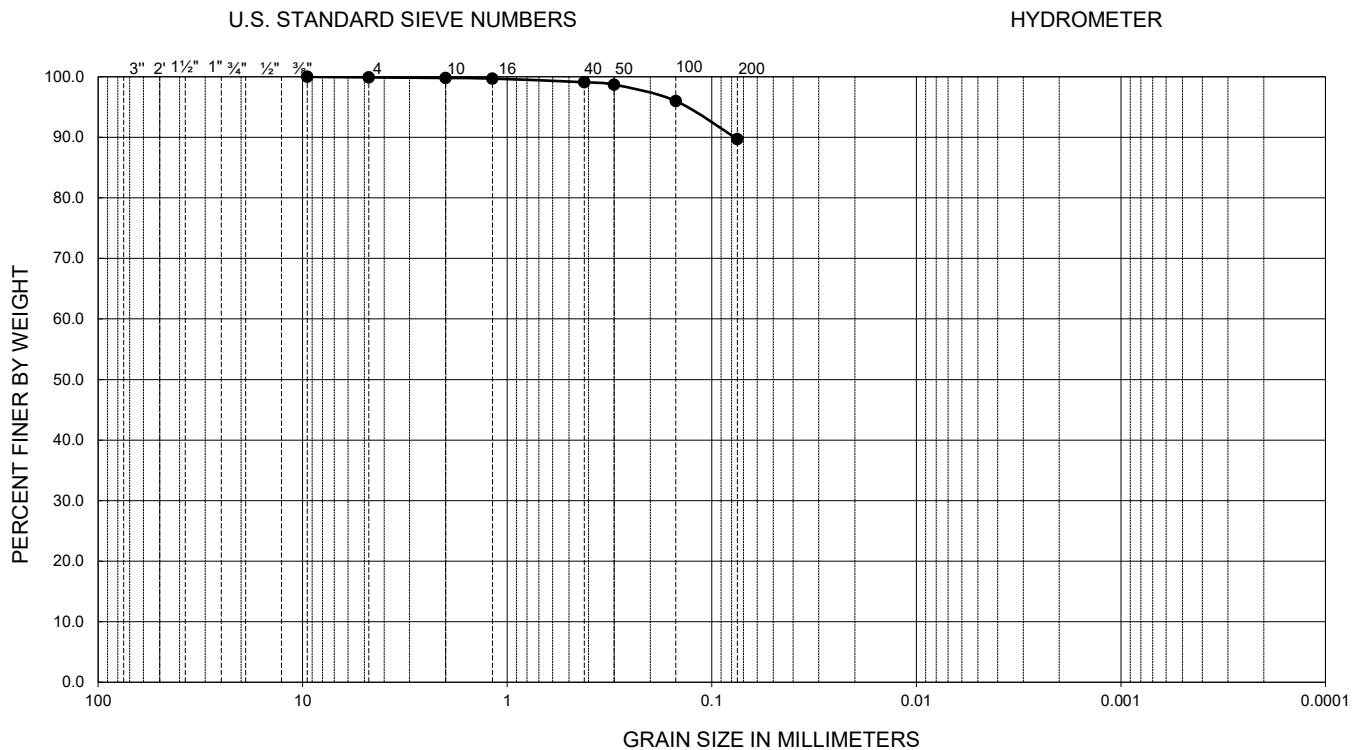
FIGURE B-9

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-HDD-01 / B-11	23.0-25.0	24	20	4	--	--	--	--	--	89.7	CL-ML

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty CLAY
0.1	10.2	89.7	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			22.2%

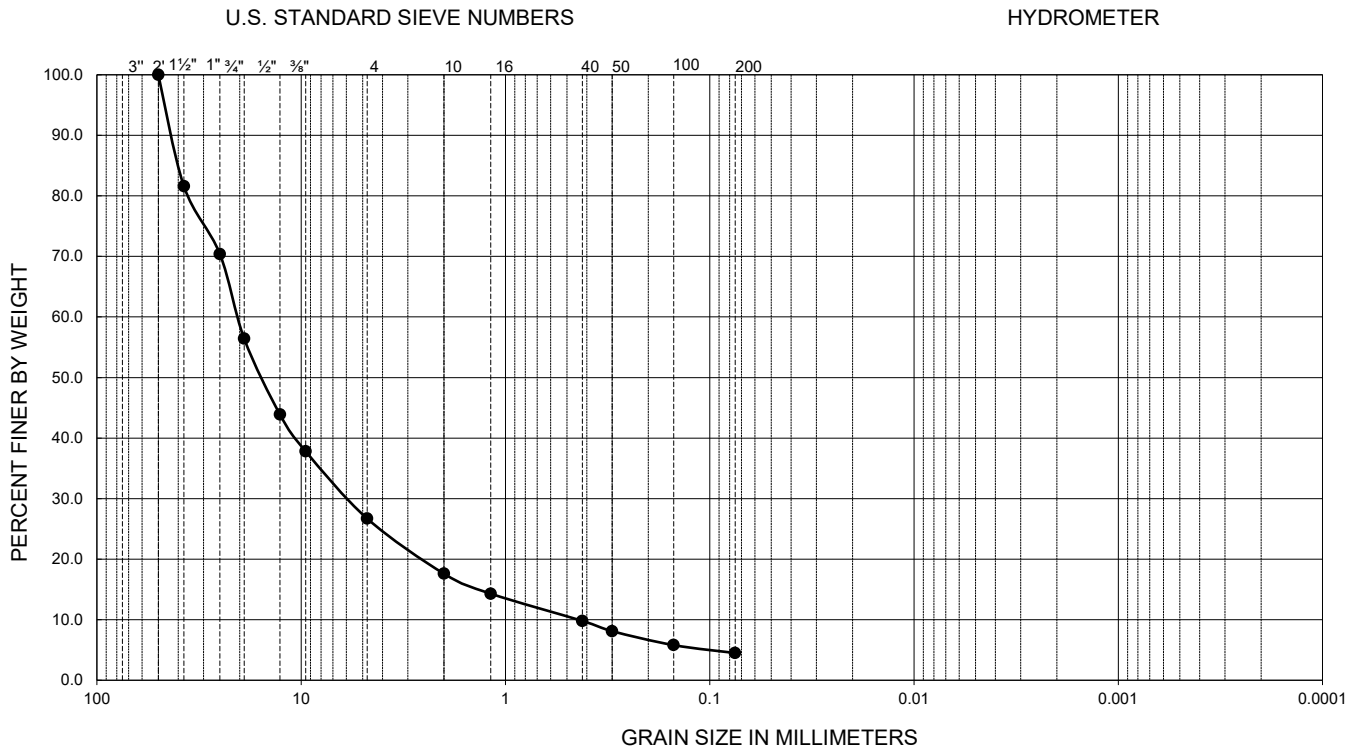
FIGURE B-10

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/2022

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-HDD-01/B-17	38.0-40.0	NP	NP	NP	0.44	5.84	20.39	46.4	3.8	4.5	GP

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Poorly graded GRAVEL with sand
73.3	22.2	4.5	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
"NP" INDICATES NON-PLASTIC			2.0%

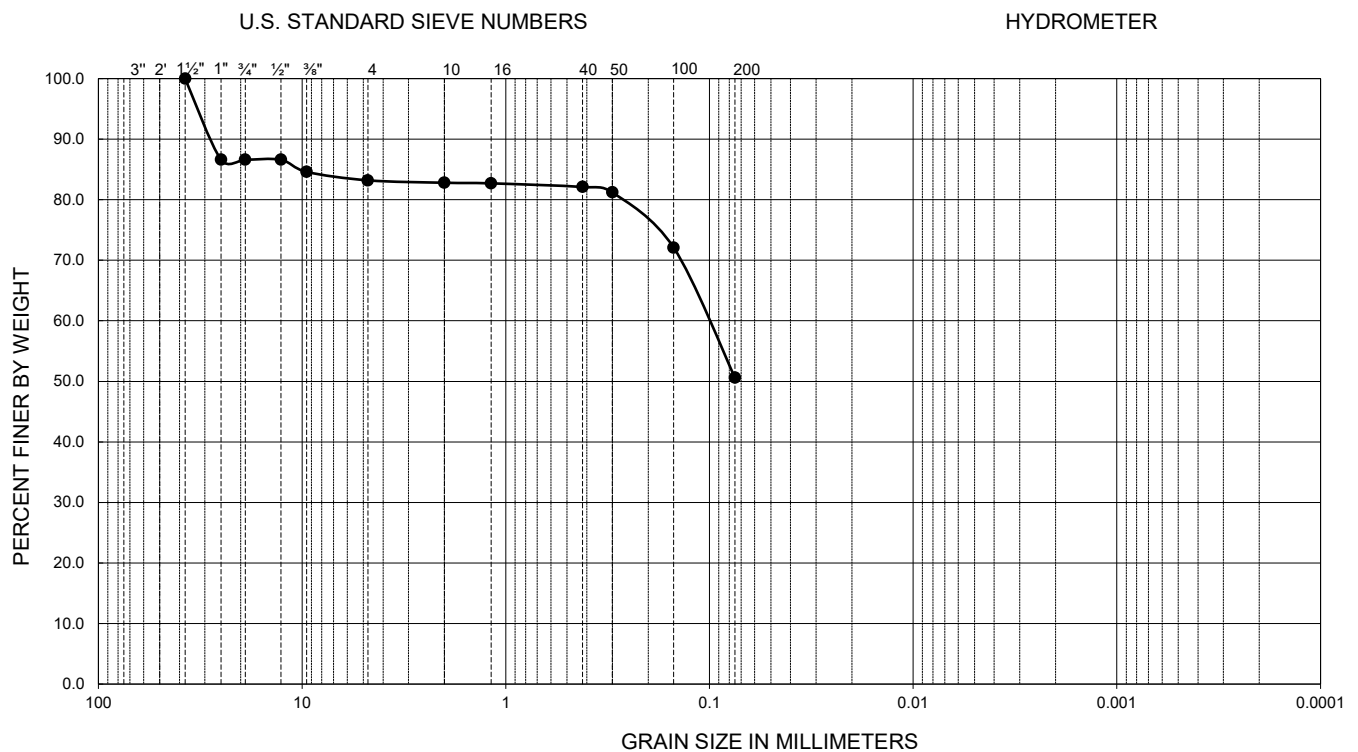
FIGURE B-11

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / SPT-06	21.5-23.0	NP	NP	NP	--	--	0.10	--	--	50.6	ML

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	Sandy SILT with gravel	
16.8	32.6	50.6		
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content	
			21.1%	

"NP" INDICATES NON-PLASTIC

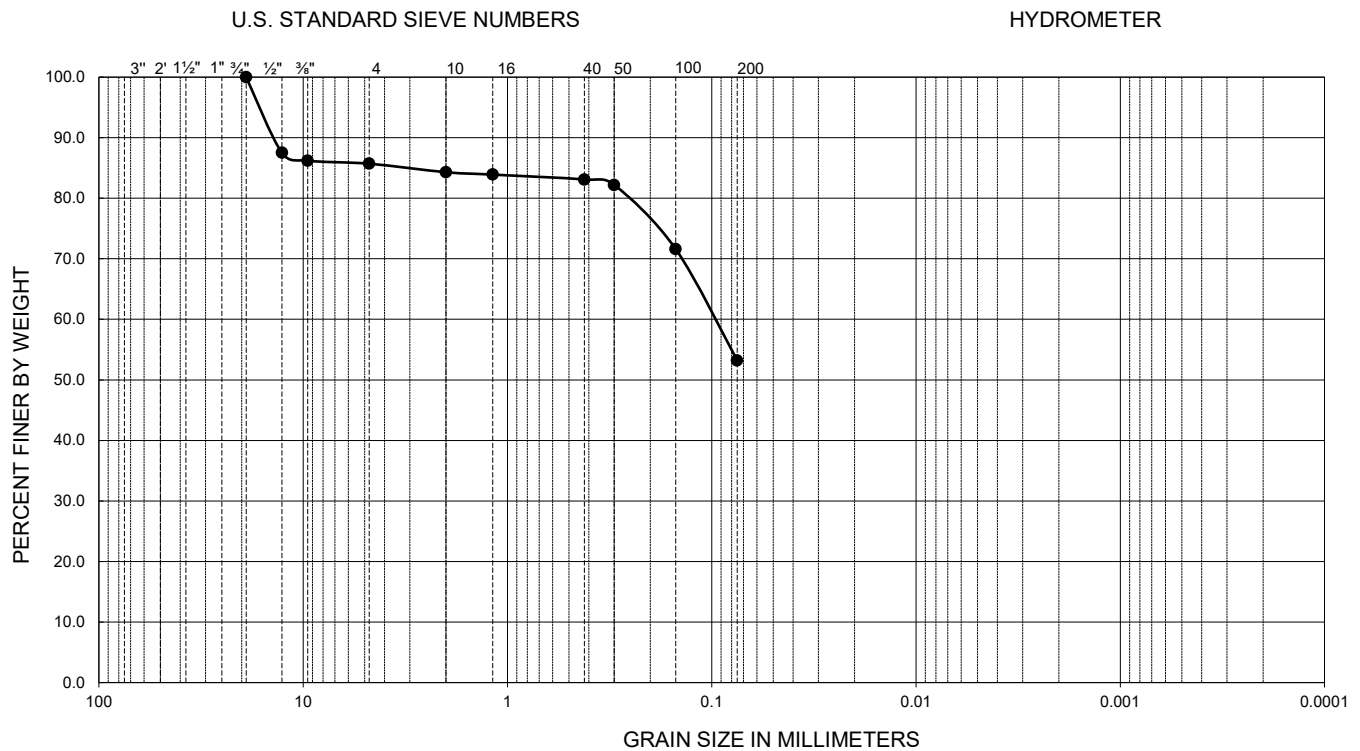
FIGURE B-12

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / SPT-10	26.5-28.0	NP	NP	NP	--	--	0.10	--	--	53.2	ML

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	Sandy SILT	
14.3	32.5	53.2		
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content	
			20.2%	

"NP" INDICATES NON-PLASTIC

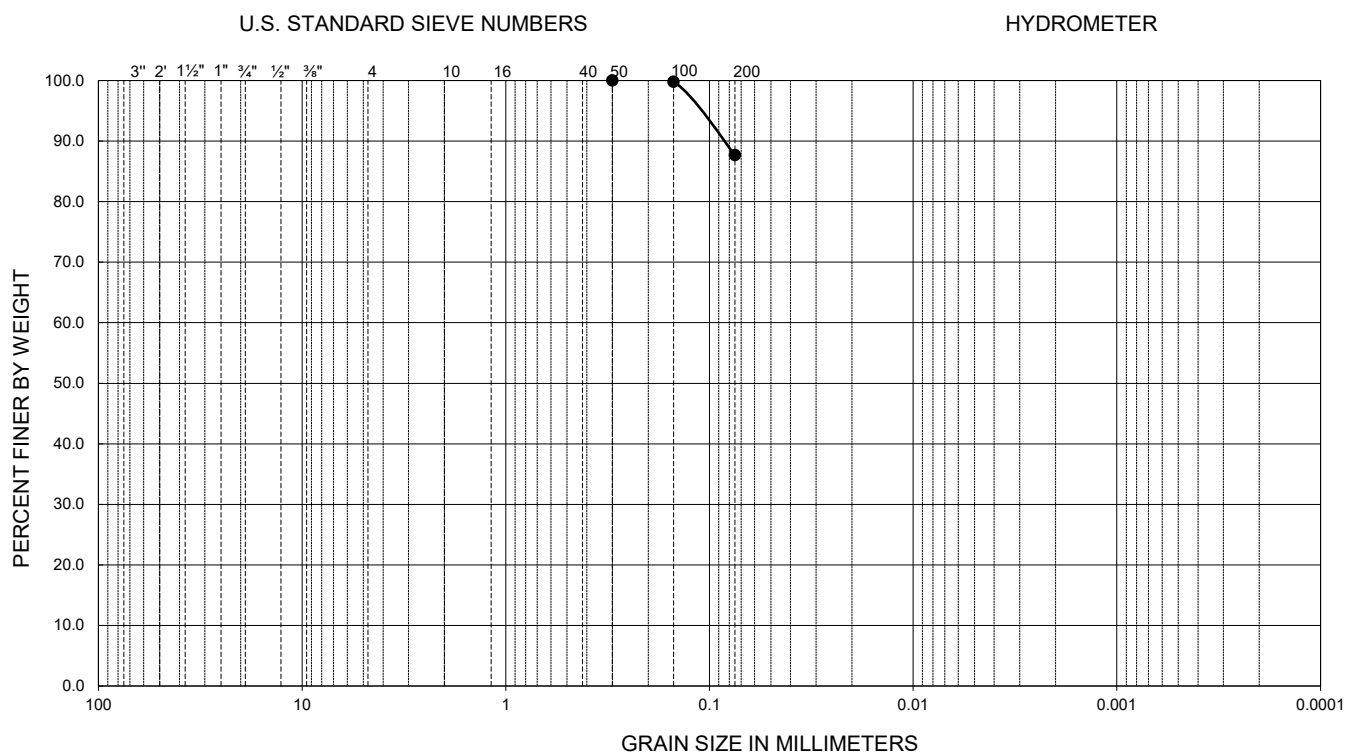
FIGURE B-13

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / SH-18	56.5-58.5	26	22	4	--	--	--	--	--	87.7	ML

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	SILT	
0.0	12.3	87.7	Moisture Content	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			23.2%	

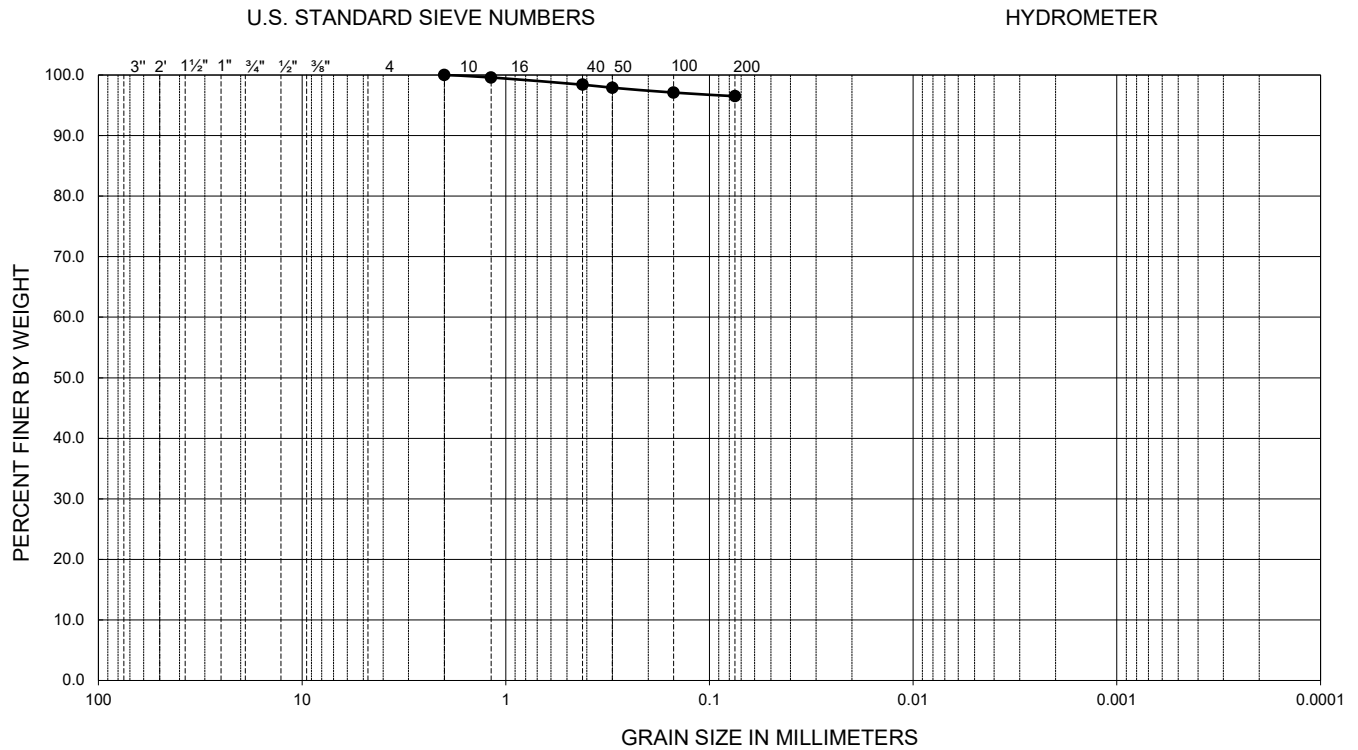
FIGURE B-14

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / SH-21	66.5-68.5	48	24	24	--	--	--	--	--	96.5	CL

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	Lean CLAY	
0.0	3.5	96.5		
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content	
			35.6%	

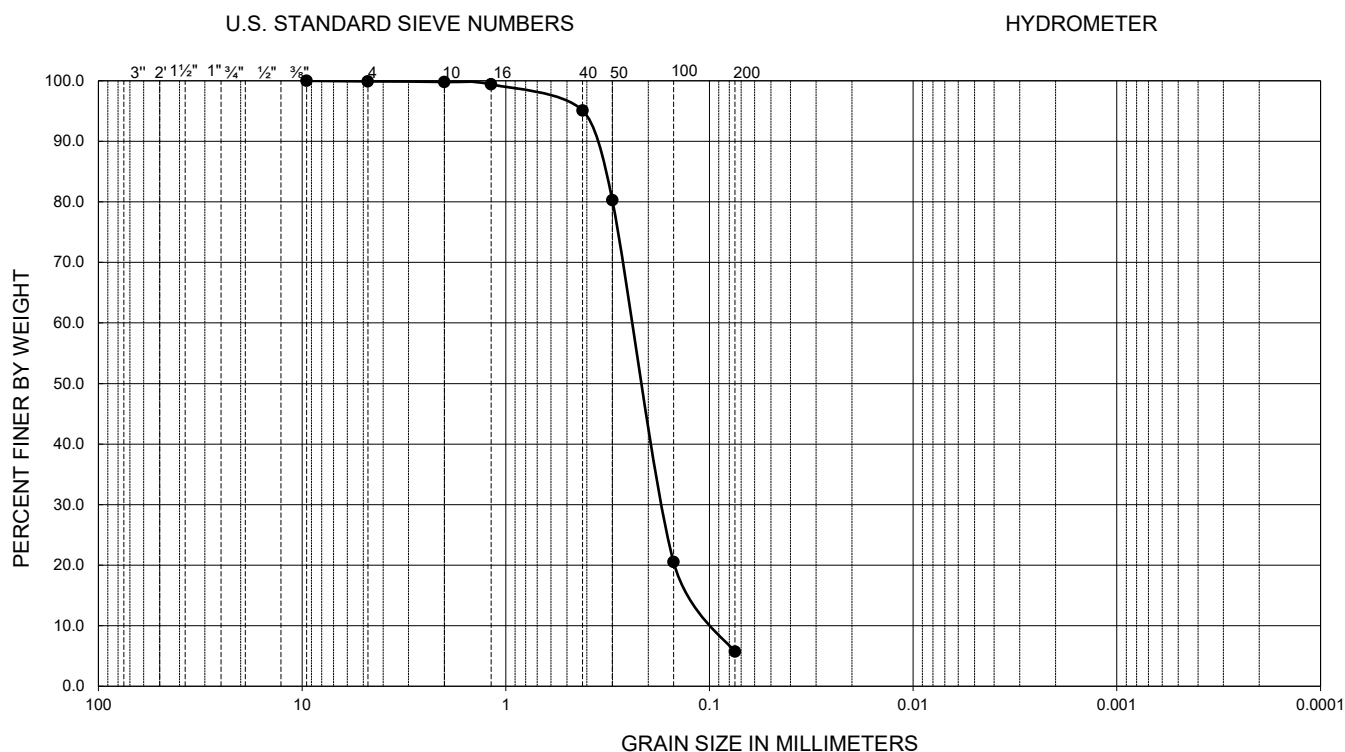
FIGURE B-15

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / B-24	74.0-76.0	--	--	--	0.09	0.17	0.24	2.6	1.3	5.7	SP-SM

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Poorly graded SAND with silt
0.1	94.2	5.7	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content
			4.0%

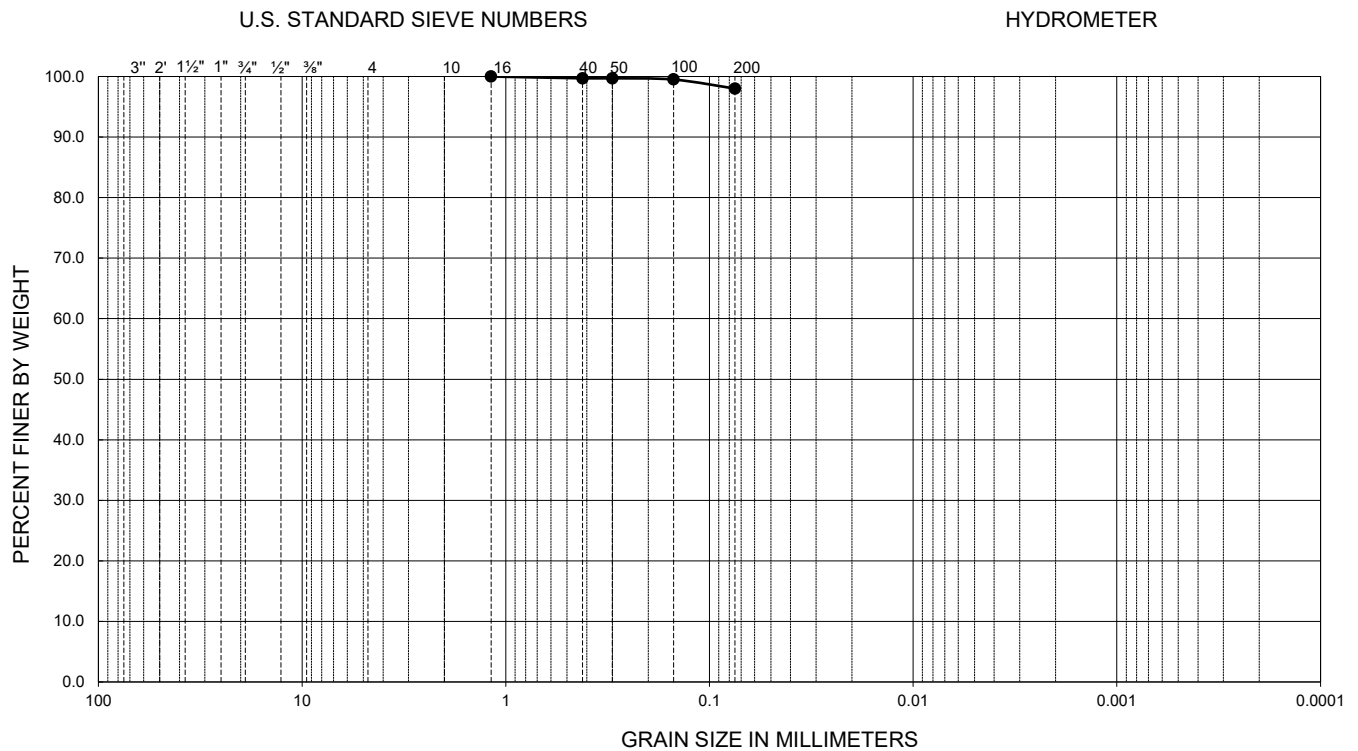
FIGURE B-16

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / B-31	98.8-100.0	31	19	12	--	--	--	--	--	98.0	CL

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	Lean CLAY	
0.0	2.0	98.0		
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content	
			27.6%	

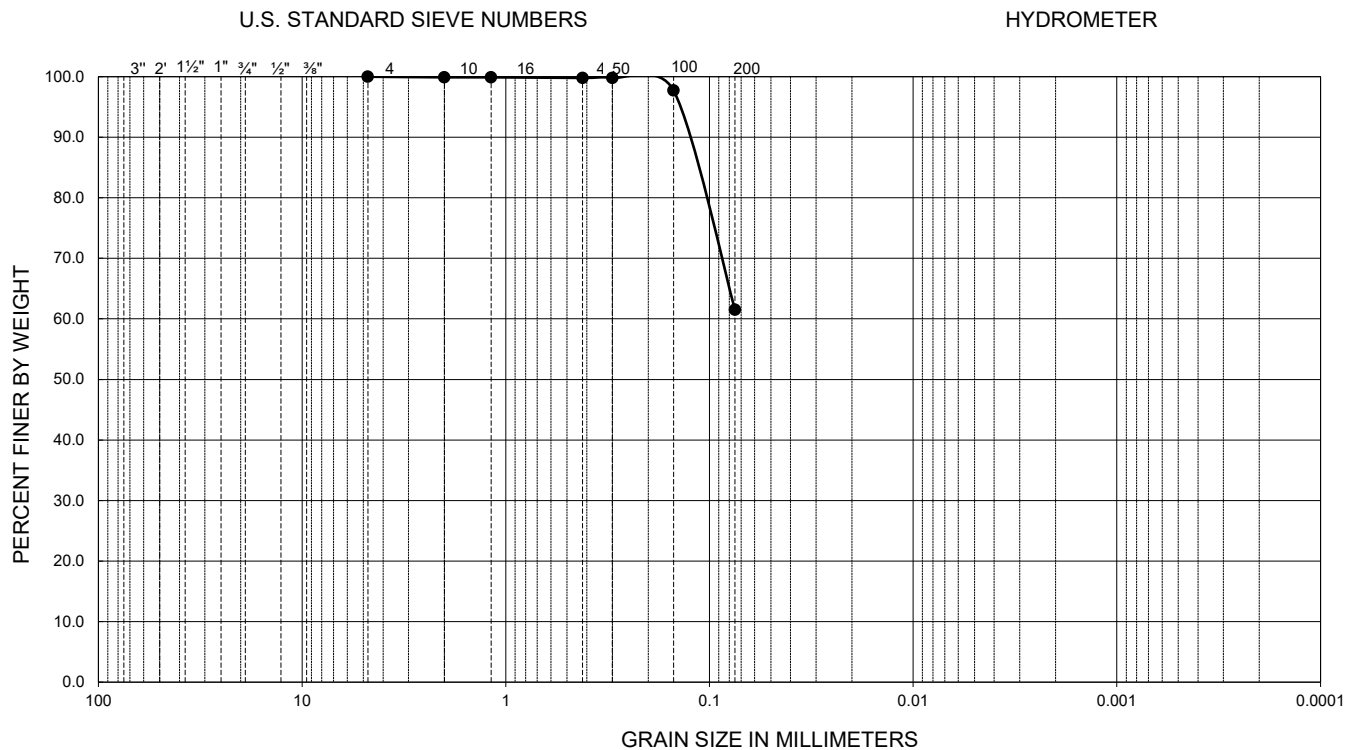
FIGURE B-17

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-01 / SPT-33	106.5-108.0	--	--	--	--	--	--	--	--	61.5	ML

Material Percent by Weight			Soil Type	
Gravel	Sand	Fines	Sandy SILT	
0.0	38.5	61.5		
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D422			Moisture Content	
			22.4%	

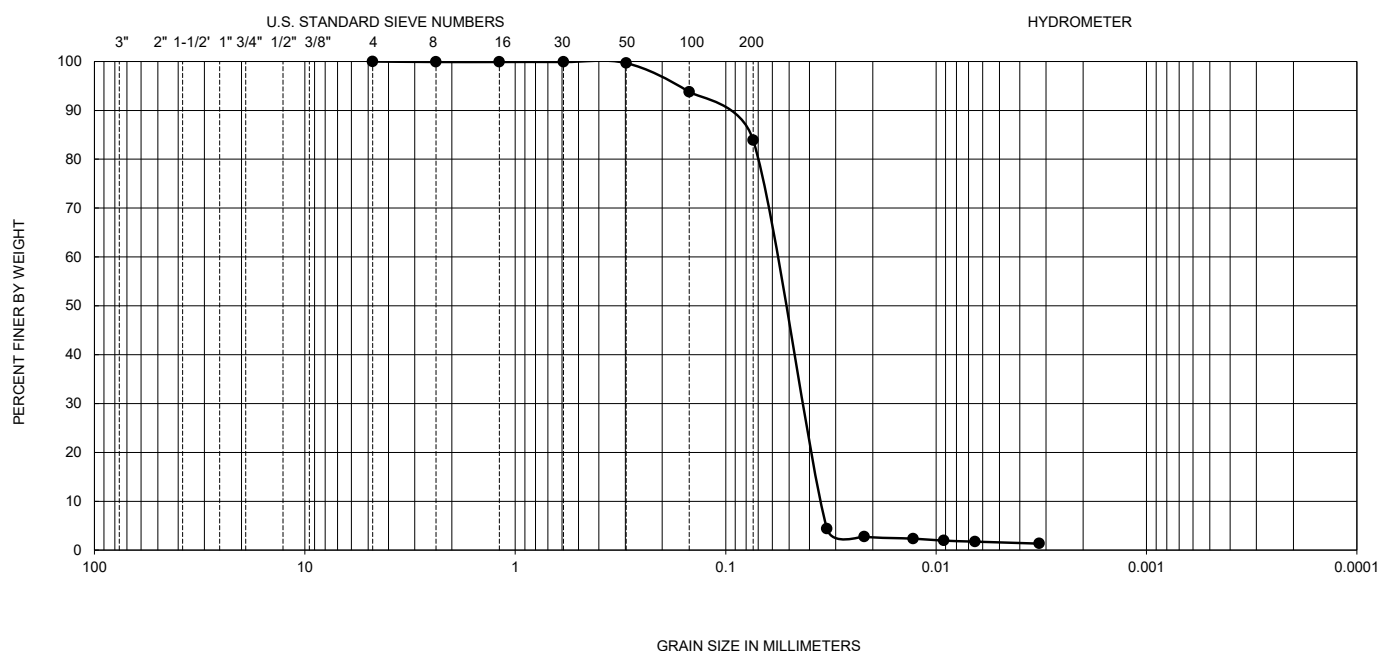
FIGURE B-18

GRADATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179001 | 4/22

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

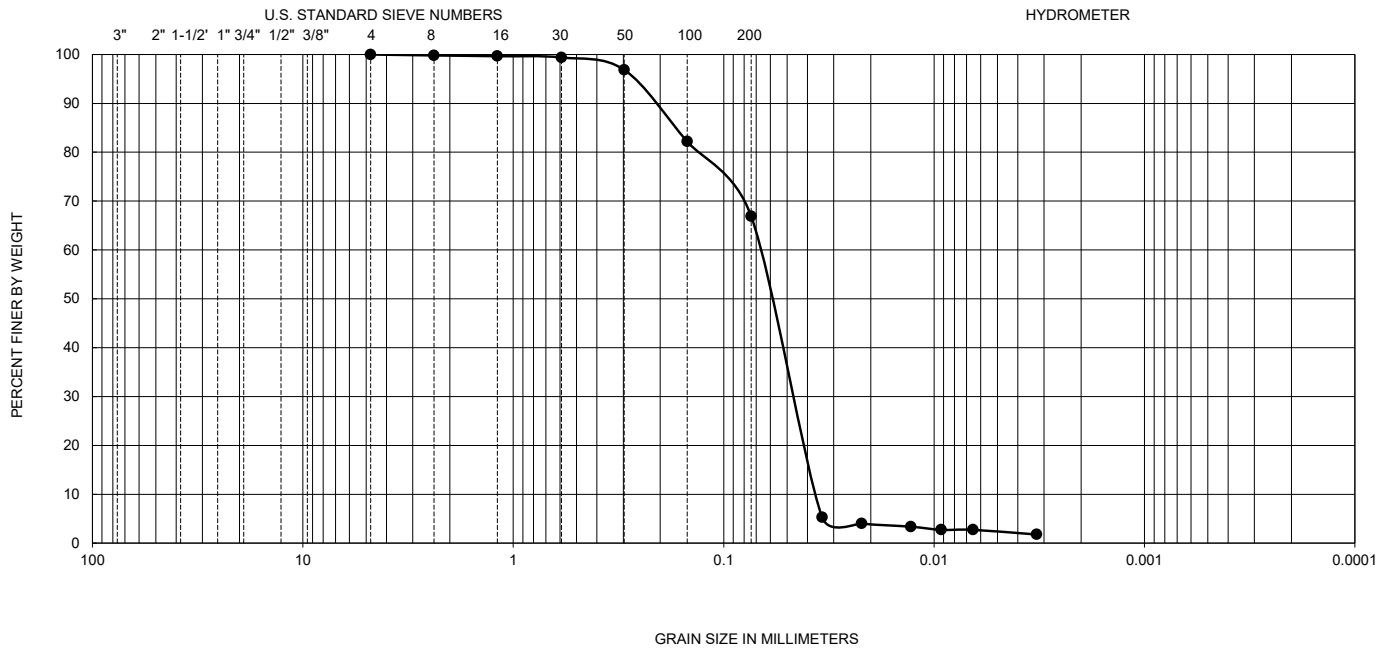


Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (percent)	USCS
●	DH22-WTP-02 SPT-07	22.0-24.0	NP	NP	NP	--	--	--	--	--	84	ML

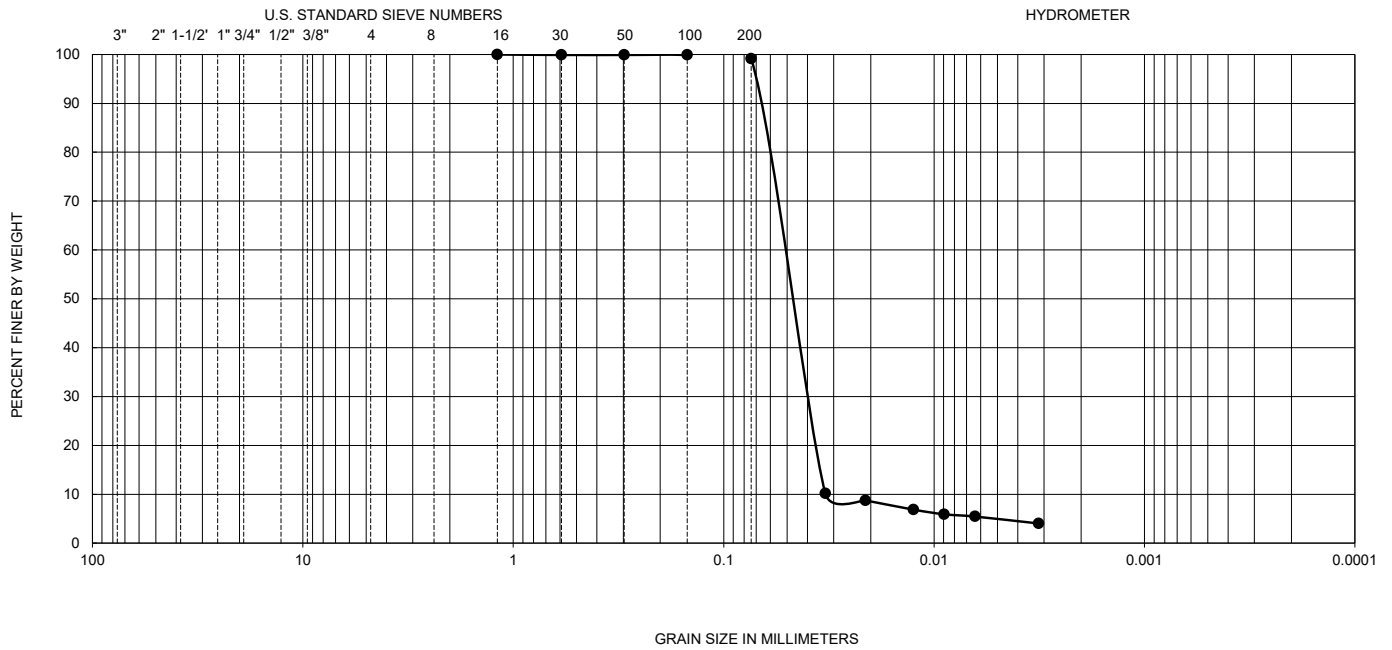
GRADATION PERFORMED IN GENERAL ACCORDANCE WITH ASTM D6913
HYDROMETER PERFORMED IN GENERAL ACCORDANCE WITH ASTM D7928

"NP" INDICATES NON-PLASTIC

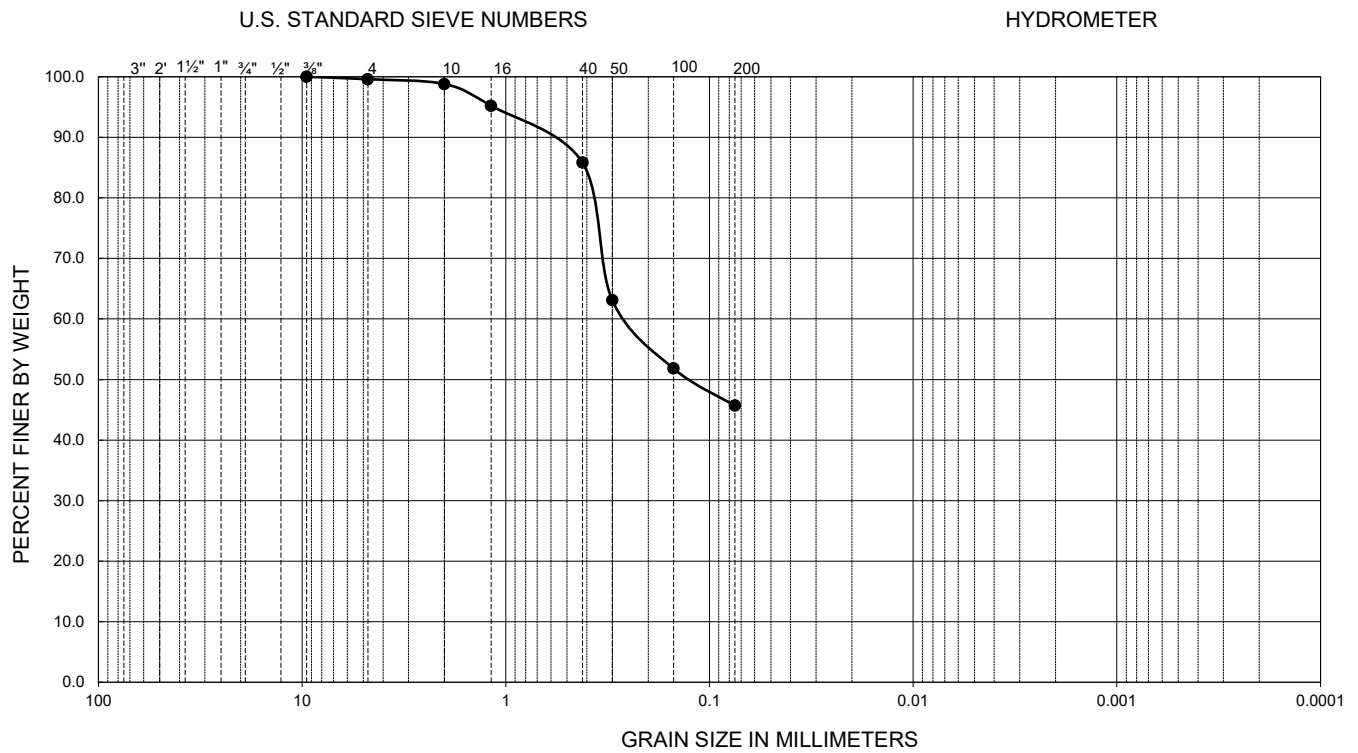
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



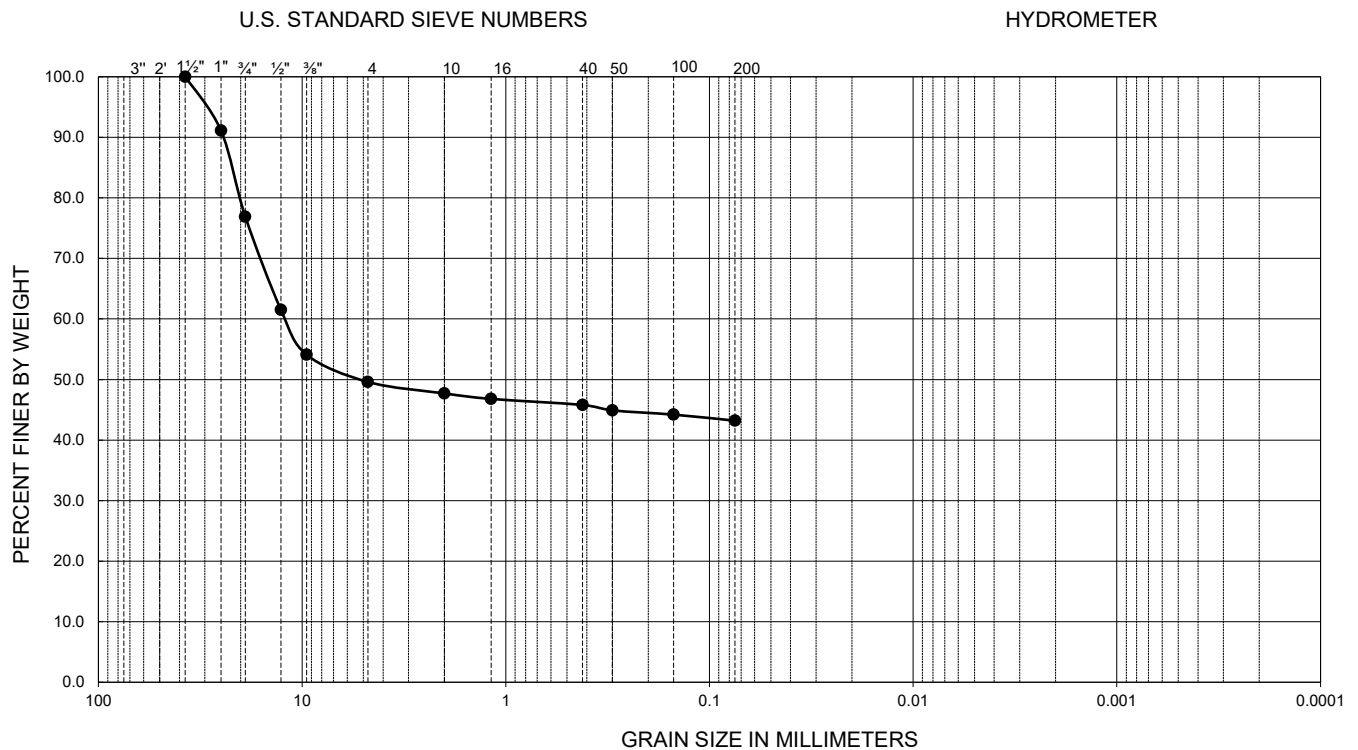
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



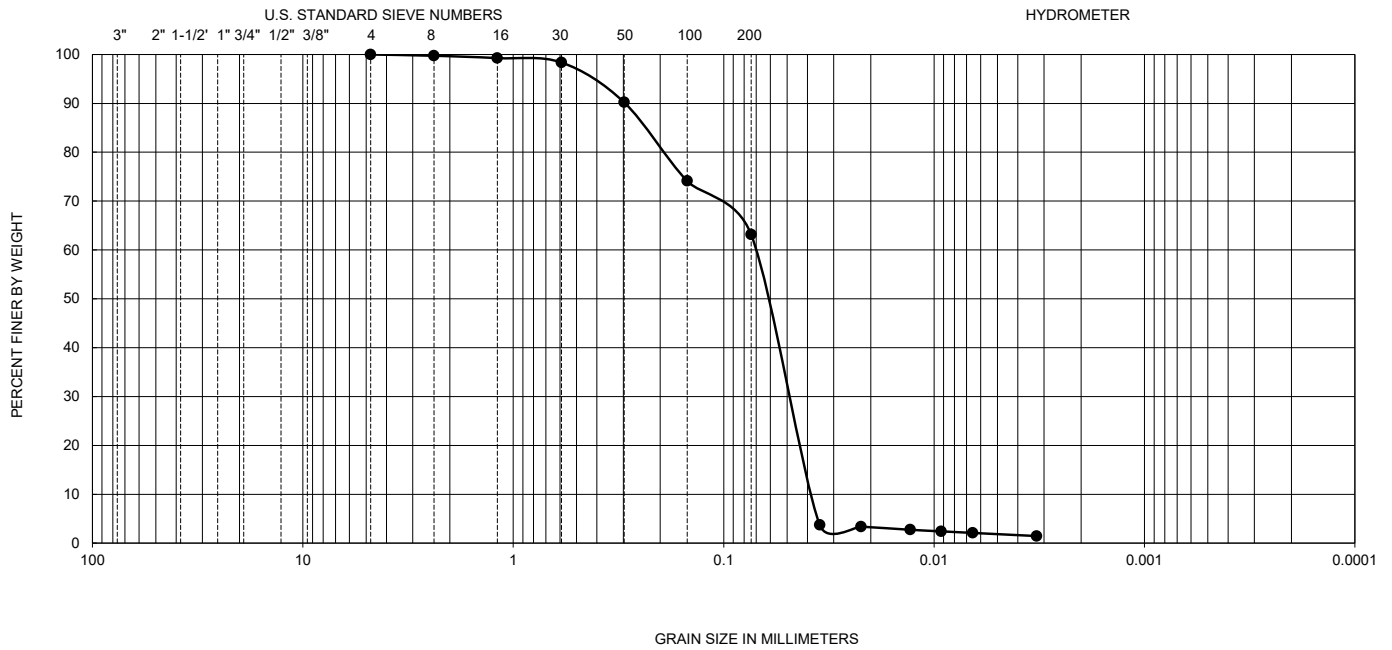
Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (%)	USCS
●	DH22-WTP-03 SPT-05	15.0-17.0	--	--	--	--	--	11.97	--	--	43.2	GM

Material Percent by Weight			Soil Type
Gravel	Sand	Fines	Silty GRAVEL
50.4	6.4	43.2	
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D6913			Moisture Content
			4.4%

FIGURE B-5

GRADATION TEST RESULTS

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



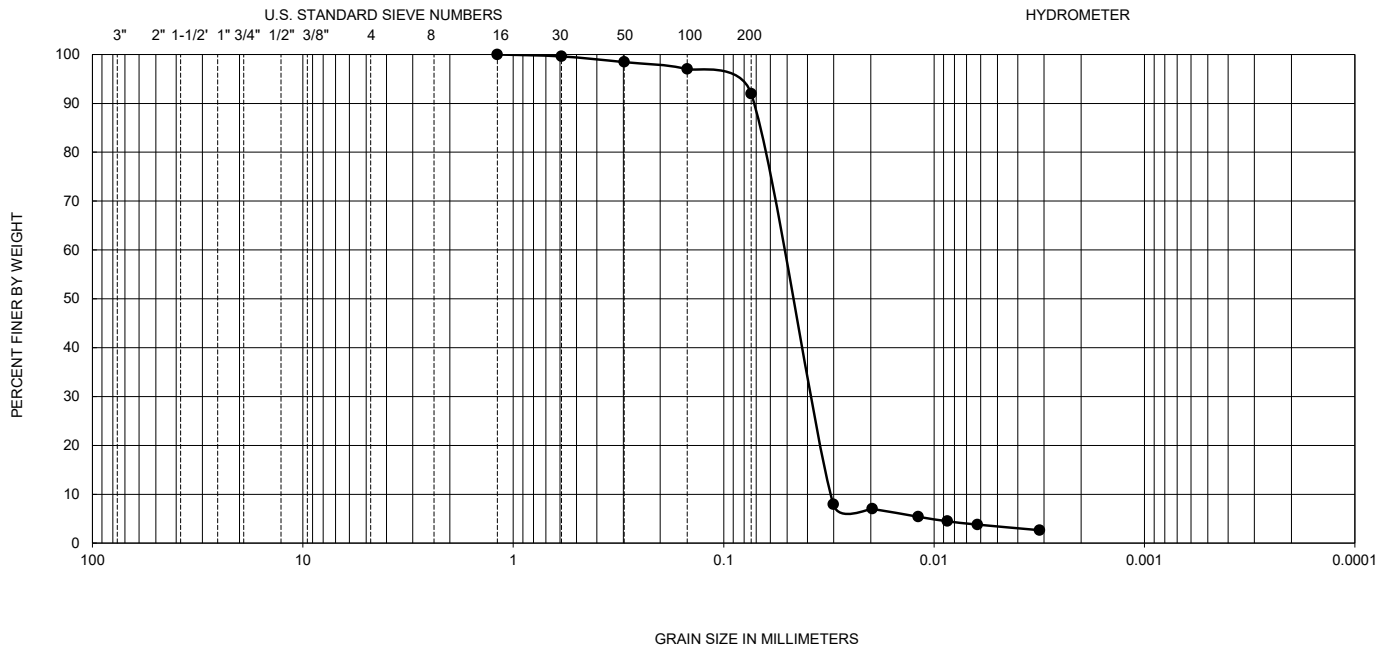
Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (percent)	USCS
●	DH22-WTP-03 SPT-06B	21.0-22.0	NP	NP	NP	--	--	--	--	--	63	ML

GRADATION PERFORMED IN GENERAL ACCORDANCE WITH ASTM D6913
HYDROMETER PERFORMED IN GENERAL ACCORDANCE WITH ASTM D7928

"NP" INDICATES NON-PLASTIC

FIGURE B-6

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY

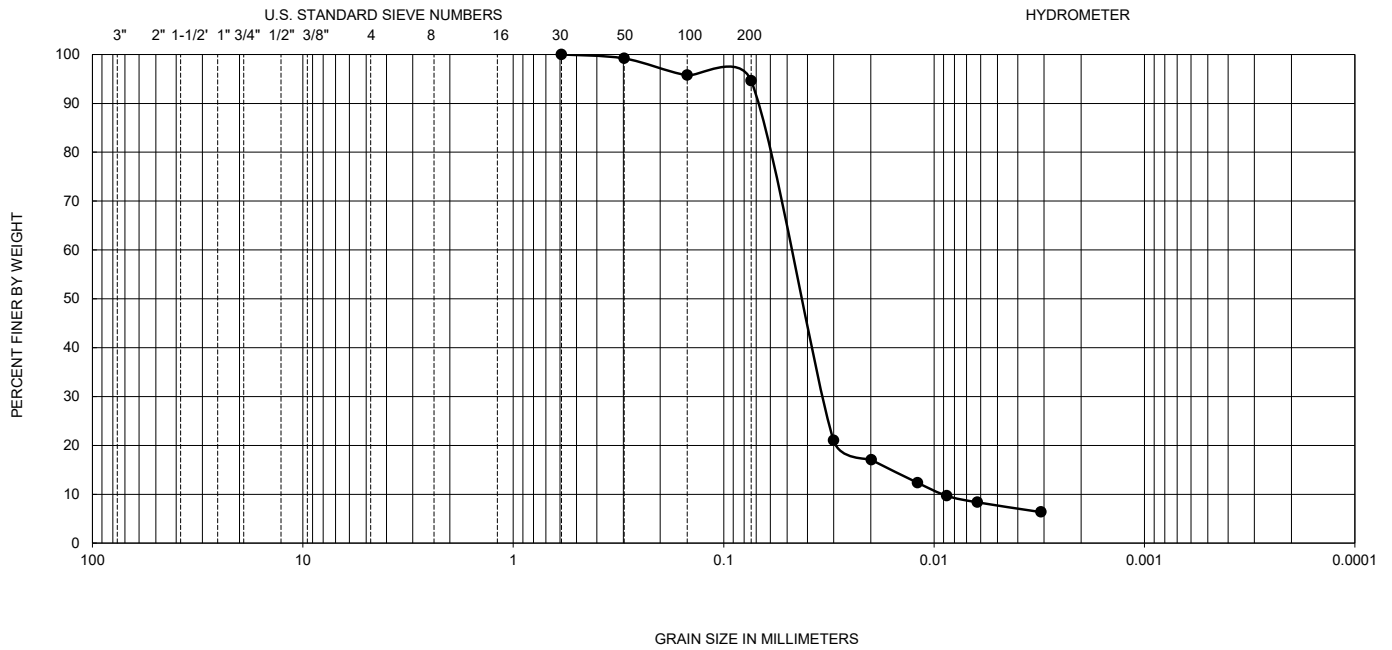


Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (percent)	USCS
●	DH22-WTP-03 SPT-08B	26.0-28.0	26	18	8	--	--	--	--	--	92	CL

GRADATION PERFORMED IN GENERAL ACCORDANCE WITH ASTM D6913
HYDROMETER PERFORMED IN GENERAL ACCORDANCE WITH ASTM D7928

FIGURE B-7

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D ₁₀	D ₃₀	D ₆₀	C _u	C _c	Passing No. 200 (percent)	USCS
●	DH22-WTP-03 SPT-14A	49.0-49.9	NP	NP	NP	--	--	--	--	--	95	ML

GRADATION PERFORMED IN GENERAL ACCORDANCE WITH ASTM D6913
HYDROMETER PERFORMED IN GENERAL ACCORDANCE WITH ASTM D7928

"NP" INDICATES NON-PLASTIC

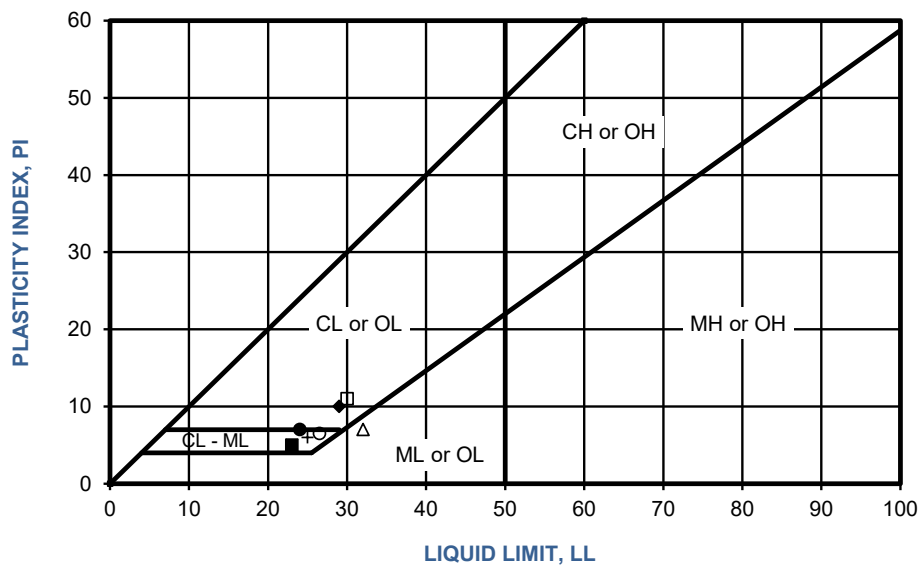
FIGURE B-8

SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	USCS (TOTAL SAMPLE)
DH-22-WTP-02 SPT-02	2.5-4.5	Lean CLAY with sand	100	71.0	CL
DH22-WTP-02 SPT-09	26.0-28.0	Silty SAND	100	36.5	SM
DH22-WTP-02 SH-01	35.0-37.0	SILT	100	92.8	ML
DH22-WTP-02 SPT-11	41.0-43.0	Sandy SILT	100	64.9	ML
DH22-WTP-02 SPT-14	47.0-49.0	SILT	100	90.1	ML
DH22-WTP-02 SH-04	71.0-73.0	SILT	100	89.3	ML
DH-22-WTP-03 SPT-07	24.0-26.0	Silty SAND	100	43.3	SM
DH-22-WTP-03 SPT-09	36.0-38.0	Lean CLAY	100	97	CL
DH-22-WTP-03 SPT-13A	44.0-45.0	SILT	100	92.3	ML

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D1140

FIGURE B-9

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	DH22-P-01 / BK-01	3.0-5.0	24	17	7	CL-ML	CL-ML
■	DH22-P-01 / B-03	8.5-9.0	23	18	5	CL-ML	CL-ML
◆	DH22-P-02 / BK-02	3.0-6.0	29	19	10	CL	CL
○	DH22-P-02 / B-04	10.0-11.0	27	20	7	CL-ML	CL-ML
□	DH22-P-02 / B-06	14.0-15.0	30	19	11	CL	CL
Δ	DH22-P-03 / B-01	4.0-6.0	32	25	7	ML	SM
x	DH22-HDD-01 / SPT-04	6.5-8.0	23	18	5	CL-ML	CL-ML
+	DH22-HDD-01 / B-08	14.0-16.0	25	19	6	CL-ML	CL-ML

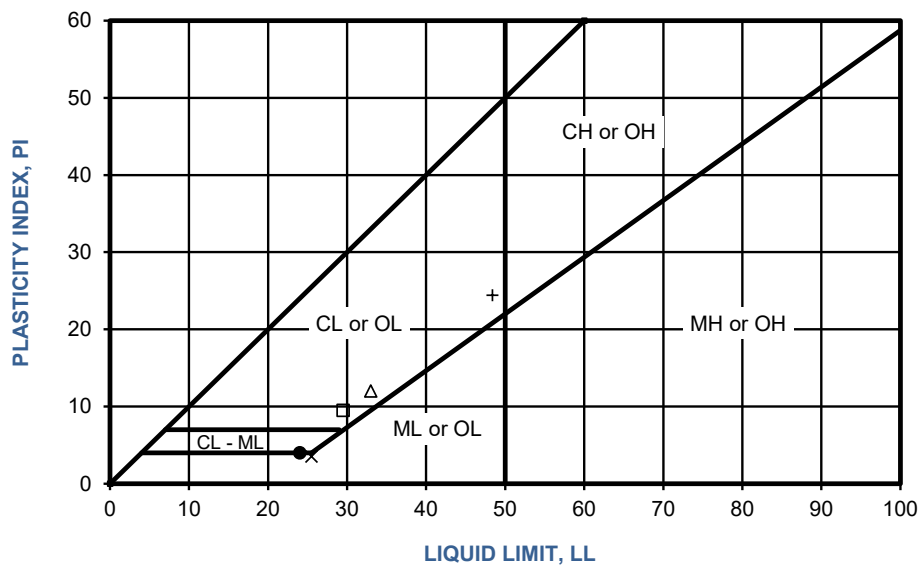


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-19

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	DH22-HDD-01 / B-11	23.0-25.0	24	20	4	CL-ML	CL-ML
■	DH22-HDD-01 / B-17	38.0-40.0	NP	NP	NP	ML	GP
◆	DH22-WTP-01 / SPT-06	21.5-23.0	NP	NP	NP	ML	ML
○	DH22-WTP-01 / SPT-10	26.5-28.0	NP	NP	NP	ML	ML
□	DH22-WTP-01 / B-12	31.5-35.0	30	20	10	CL	CL
Δ	DH22-WTP-01 / SH-13	36.5-38.5	33	21	12	CL	CL
x	DH22-WTP-01 / SH-18	56.5-58.5	26	22	4	ML	ML
+	DH22-WTP-01 / SH-21	66.5-68.5	48	24	24	CL	CL

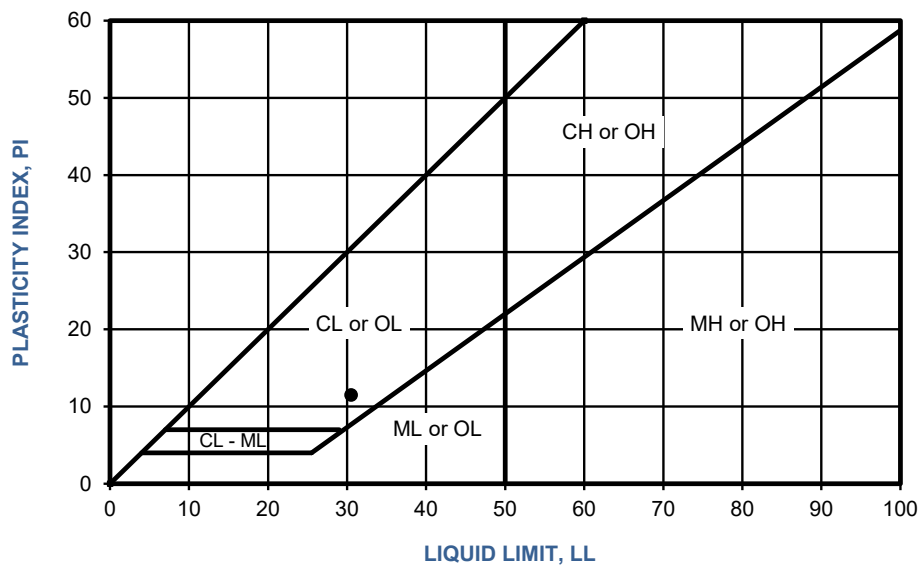
NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-20

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	DH22-WTP-01 / B-31	98.8-100.0	31	19	12	CL	CL

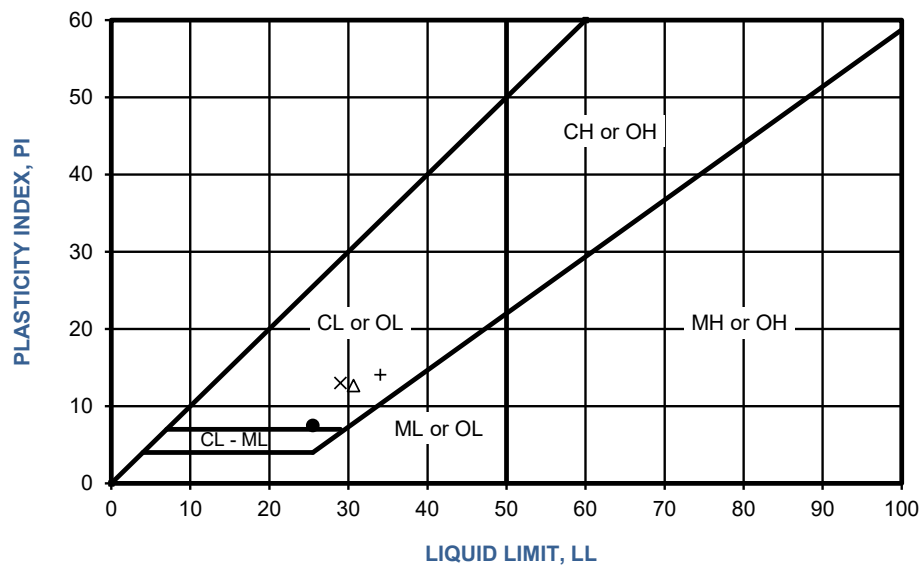


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318

FIGURE B-21

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	DH-22-WTP-02 SPT-02	2.5-4.5	26	18	8	CL	CL
	DH-22-WTP-02 MC-01	20.0-22.0	NP	NP	NP	ML	ML
	DH-22-WTP-02 SPT-07	22.0-24.0	NP	NP	NP	ML	ML
	DH-22-WTP-02 SPT-08	24.0-26.0	NP	NP	NP	ML	ML
	DH-22-WTP-02 SPT-09	26.0-28.0	NP	NP	NP	ML	SM
Δ	DH-22-WTP-02 SPT-10B	32.8-34.0	31	18	13	CL	CL
x	DH-22-WTP-02 SH-01	35.0-37.0	29	16	13	CL	CL
+	DH-22-WTP-02 SH-02	37.0-39.0	34	20	14	CL	CL

NP - INDICATES NON-PLASTIC

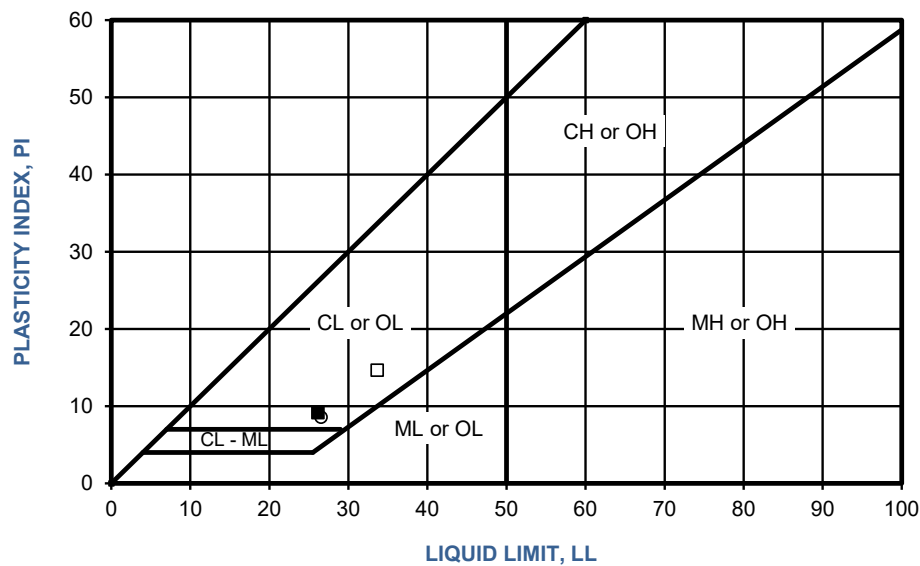


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318

FIGURE B-10

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
<div>■</div> <div>○</div> <div>□</div>	DH-22-WTP-02 SPT-11	41.0-43.0	NP	NP	NP	ML	ML
	DH-22-WTP-02 SPT-13	45.0-47.0	26	17	9	CL	CL
	DH-22-WTP-02 SPT-014	47.0-49.0	NP	NP	NP	ML	ML
	DH-22-WTP-02 SPT-16	51.0-53.0	27	18	9	CL	CL
	DH-22-WTP-02 SH-03	58.0-60.0	34	19	15	CL	CL
	DH-22-WTP-02 SH-04	71.0-73.0	NP	NP	NP	ML	ML
	DH-22-WTP-03 SPT-06B	21.0-22.0	NP	NP	NP	ML	ML
	DH-22-WTP-03 SPT-07	24.0-26.0	NP	NP	NP	ML	SM

NP - INDICATES NON-PLASTIC

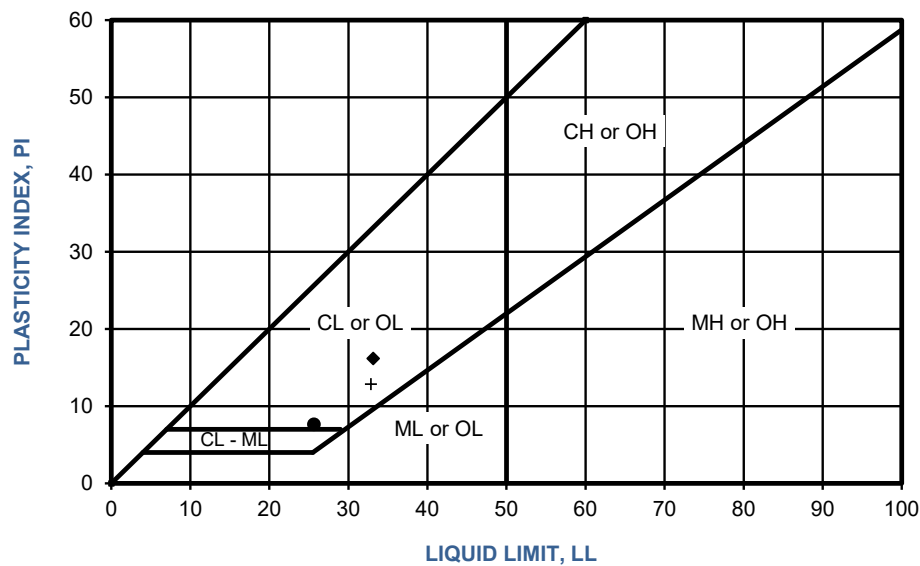


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318

FIGURE B-11

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	DH-22-WTP-03 SPT-08B	26.0-28.0	26	18	8	CL	CL
	DH-22-WTP-03 SH-01	32.0-34.0	NP	NP	NP	ML	ML
◆	DH-22-WTP-03 SPT-09	36.0-38.0	33	17	16	CL	CL
	DH-22-WTP-03 SPT-10	38.0-40.0	NP	NP	NP	ML	ML
	DH-22-WTP-03 SPT-11	40.0-42.0	NP	NP	NP	ML	ML
	DH-22-WTP-03 SPT-13A	44.0-45.0	NP	NP	NP	ML	ML
	DH-22-WTP-03 SPT-14A	49.0-49.9	NP	NP	NP	ML	ML
+	DH-22-WTP-03 SH-02	54.0-56.0	33	20	13	CL	CL

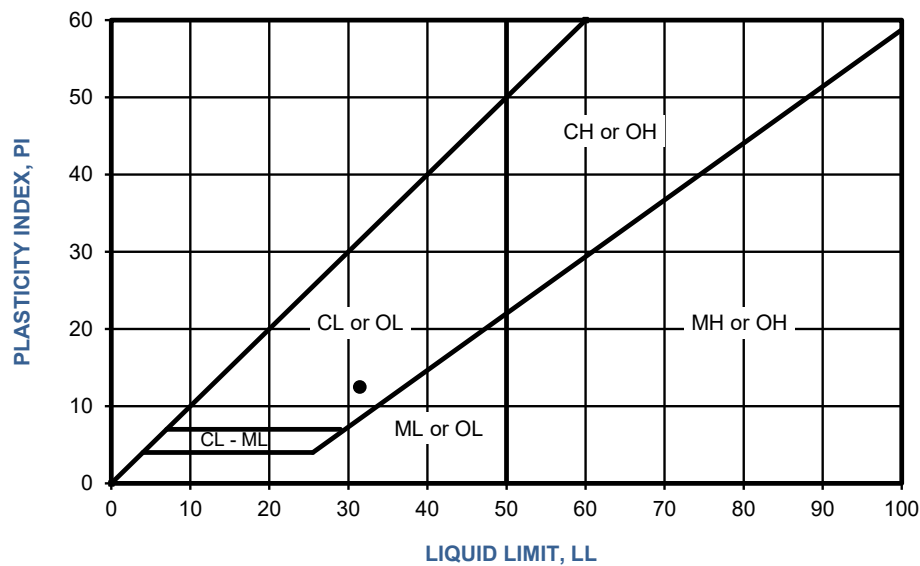
NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318

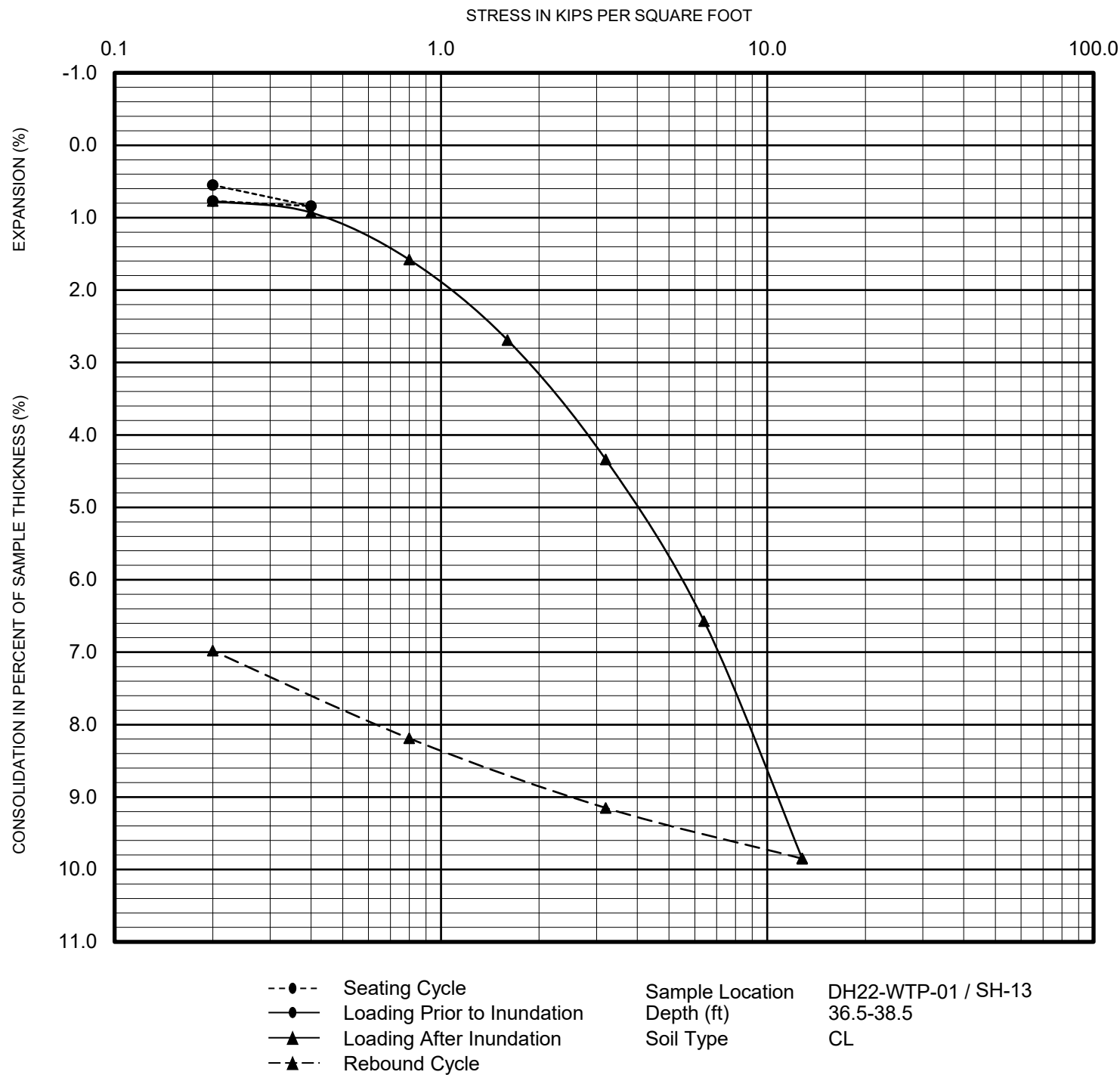
FIGURE B-12

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	DH-22-WTP-03 SH-03	62.0-64.0	31	19	12	CL	CL



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318

FIGURE B-13

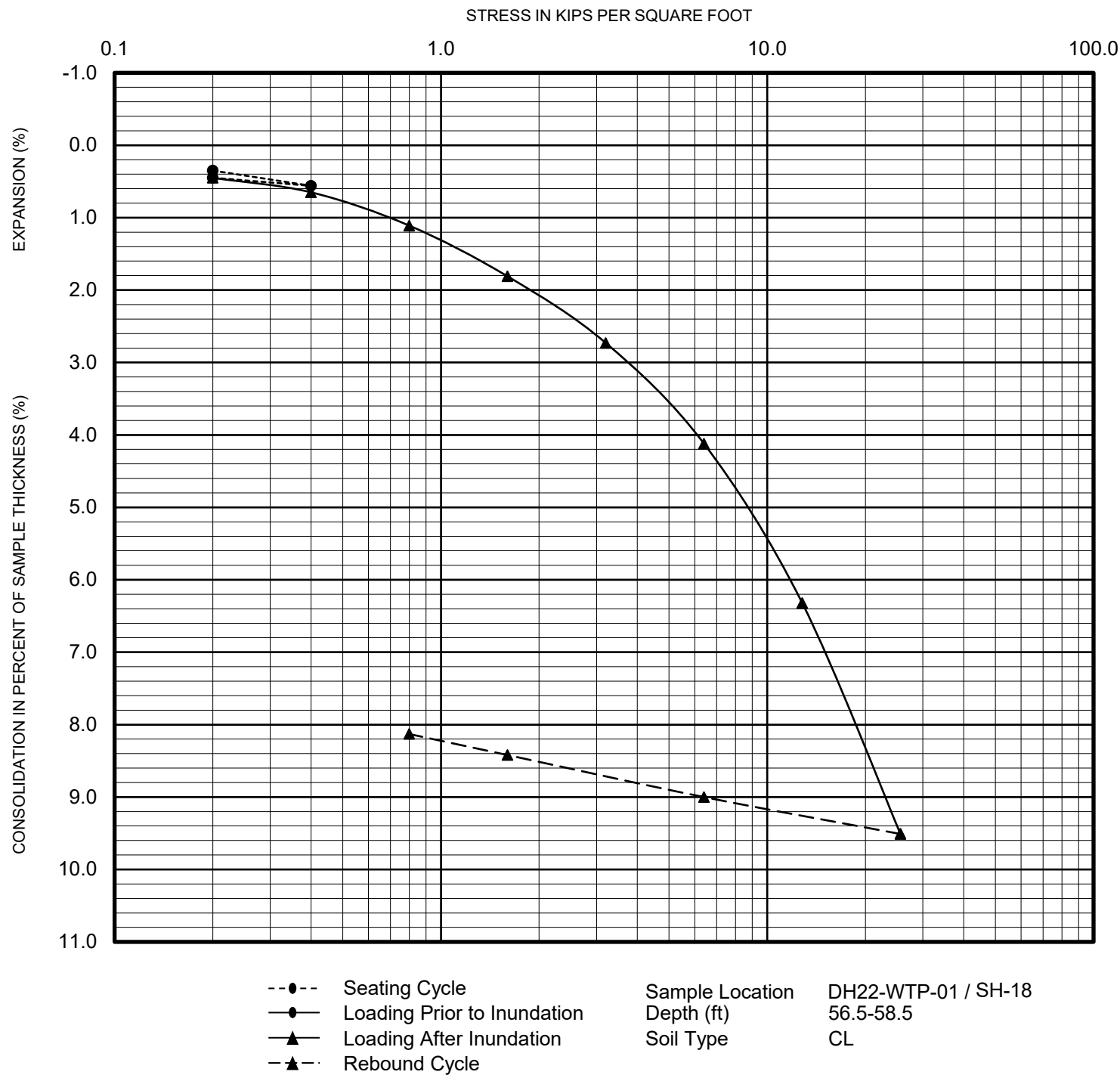


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

FIGURE B-22

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

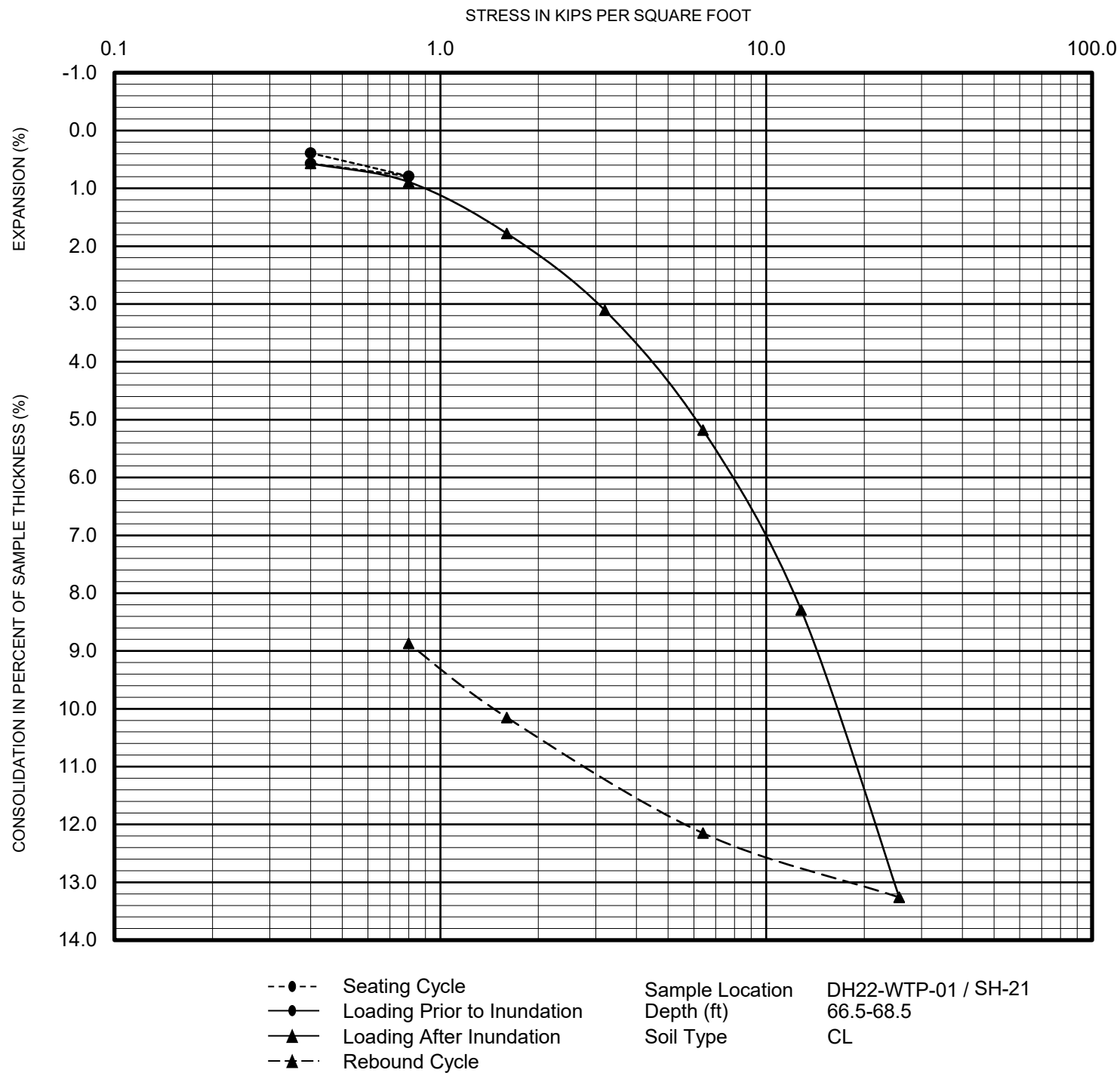


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

FIGURE B-23

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

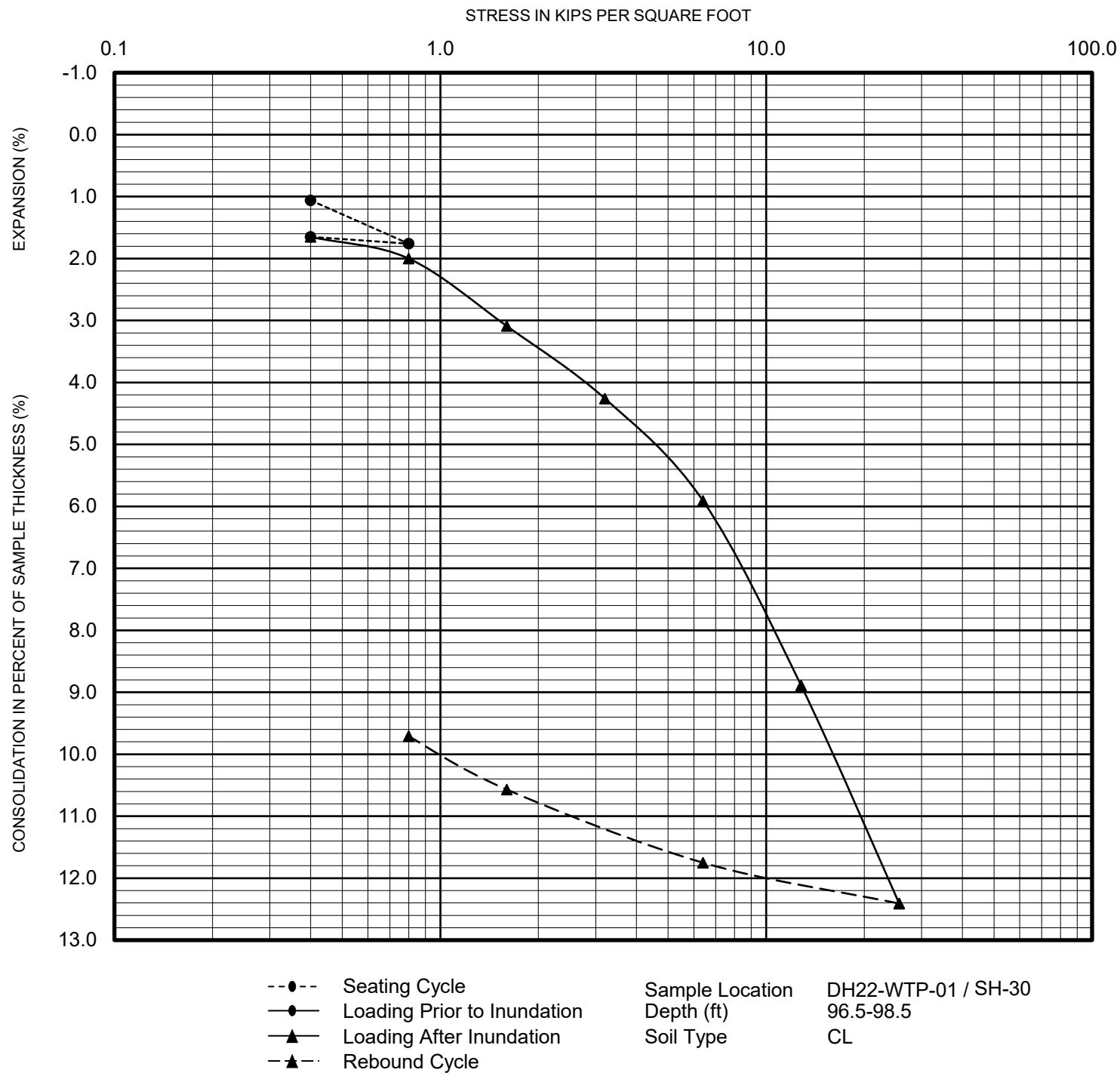


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

FIGURE B-24

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

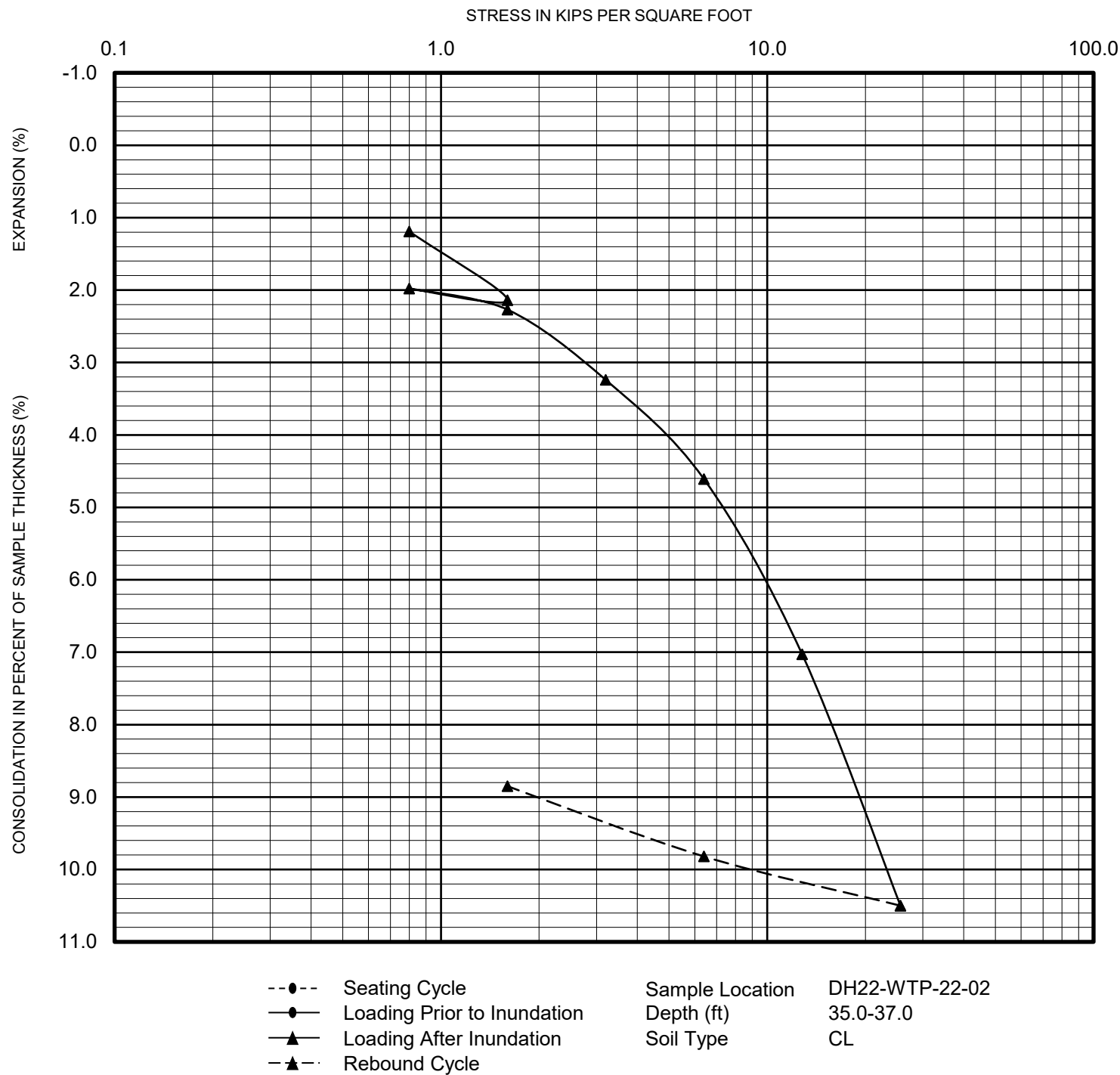


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

FIGURE B-25

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH



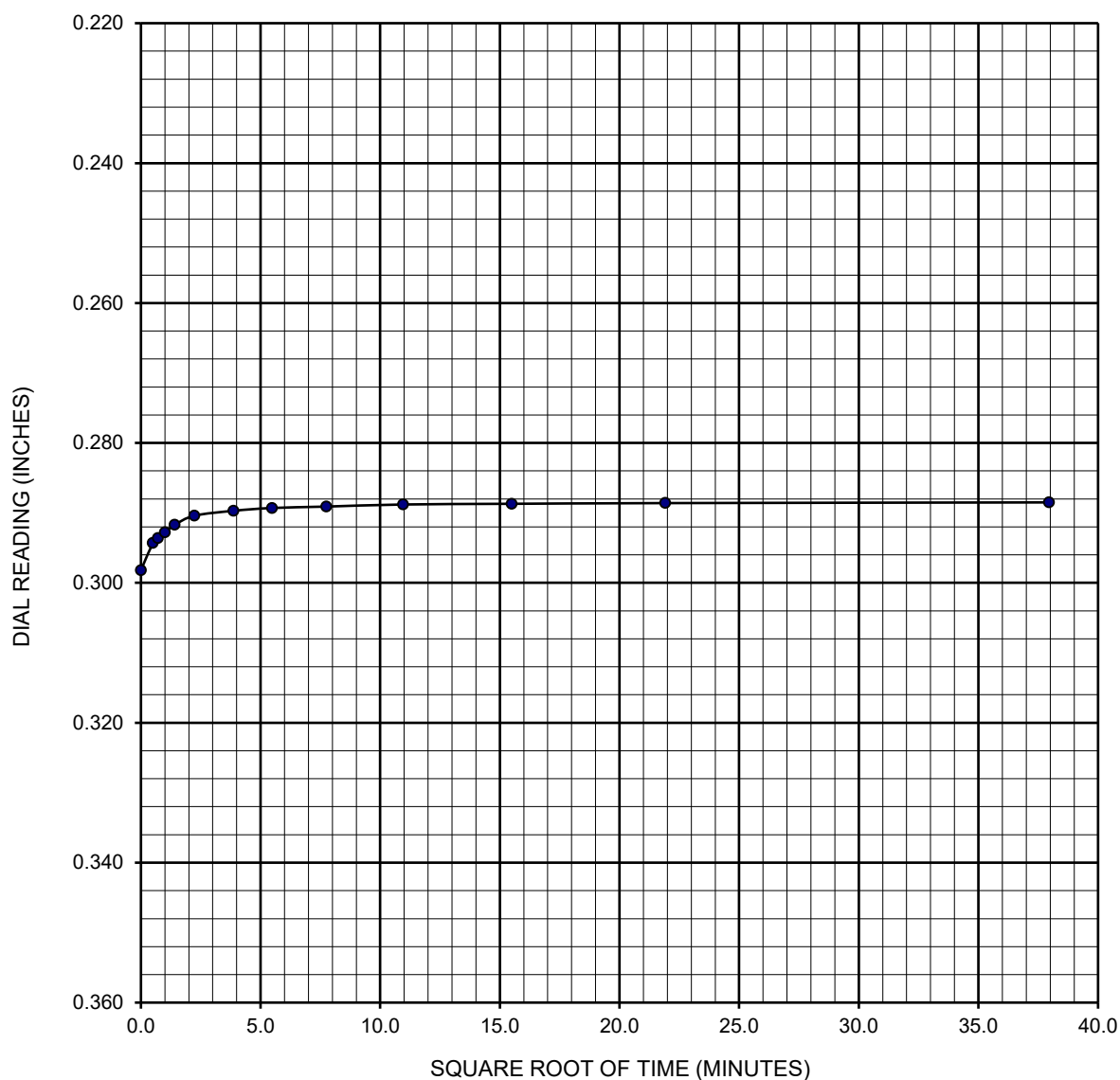
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-14

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22

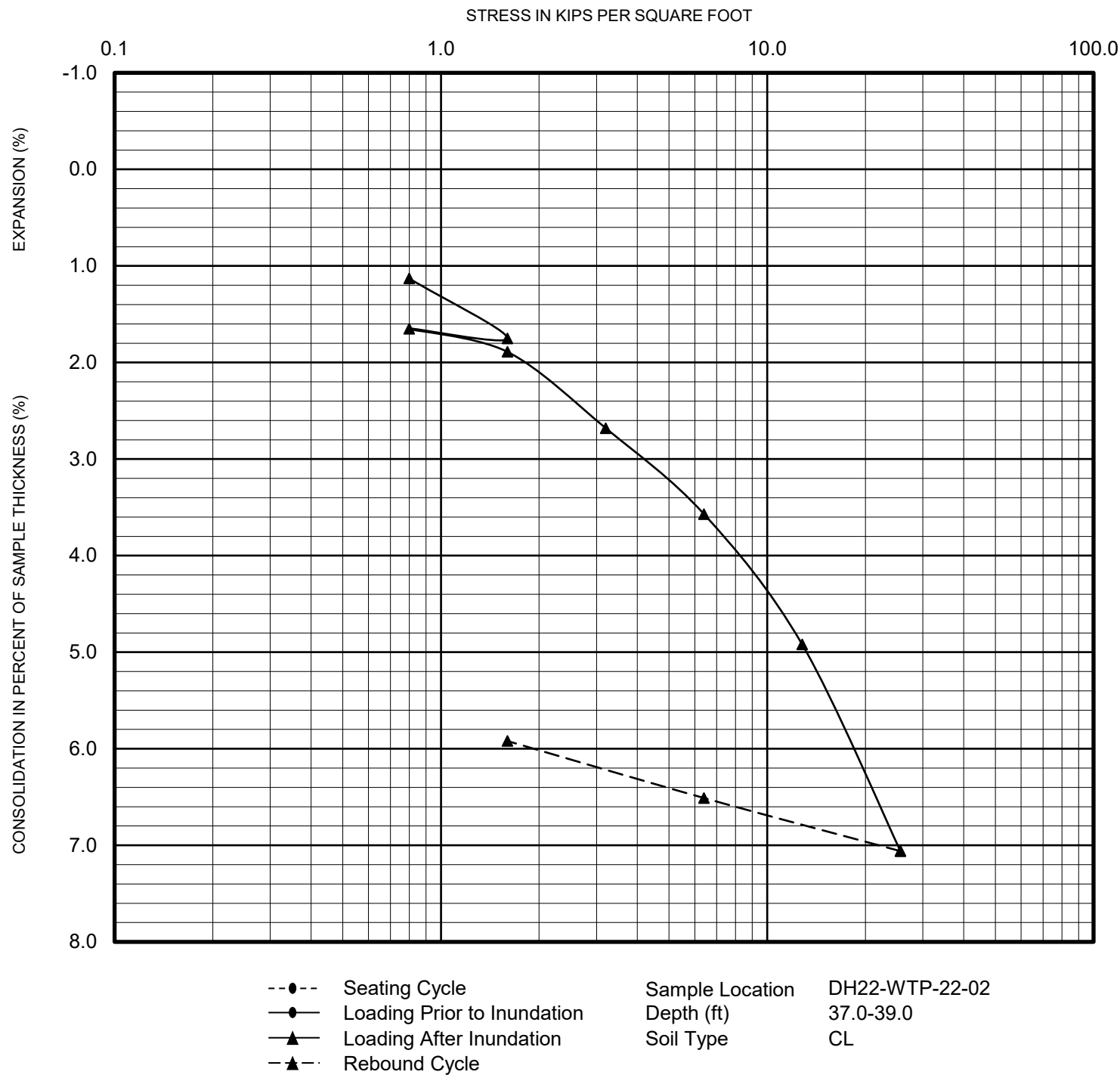


Sample Location DH22-WTP-02
 Depth (ft) 35.0-37.0

Load (ksf) 1.6
 Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-15



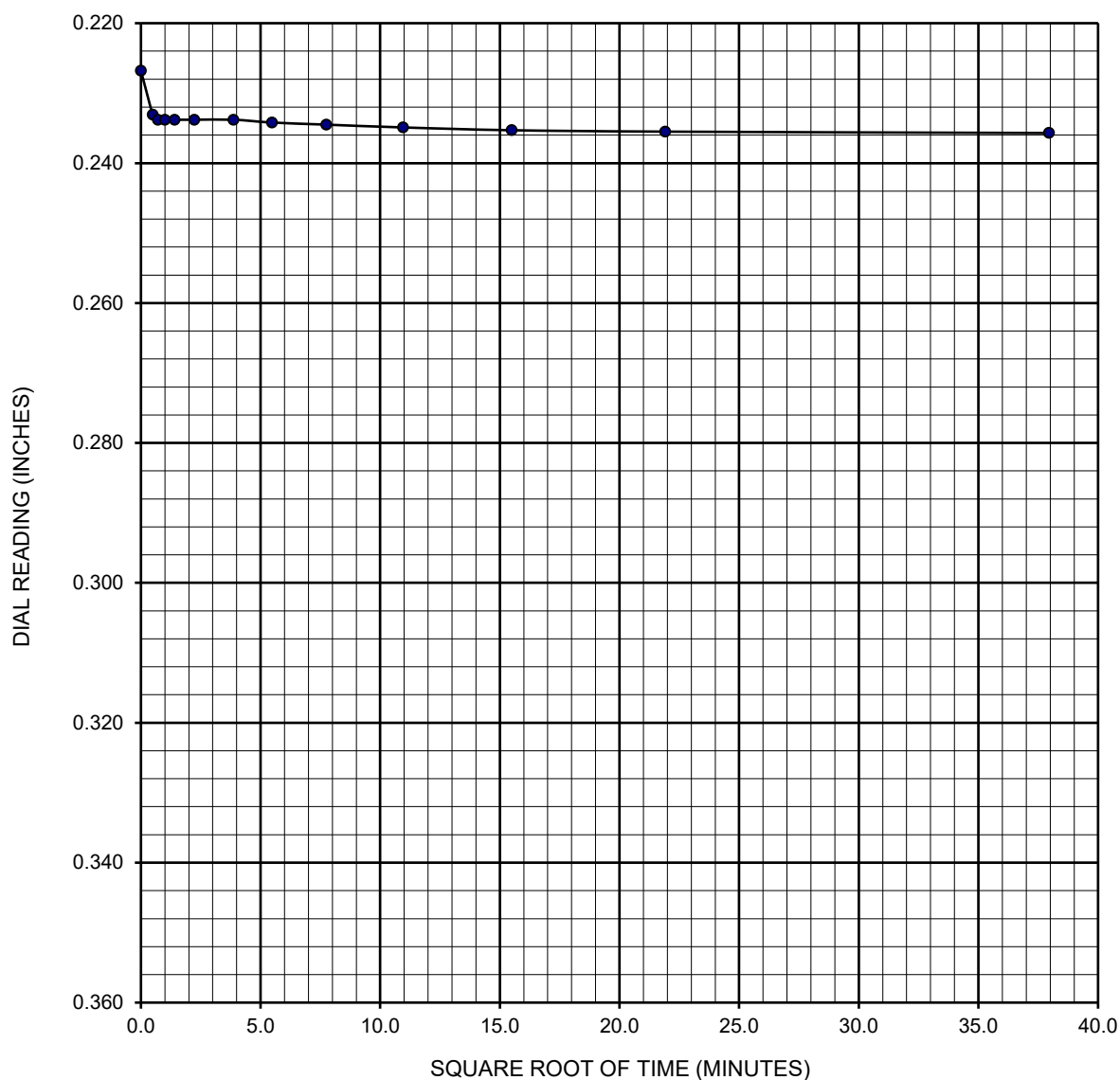
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-16

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22

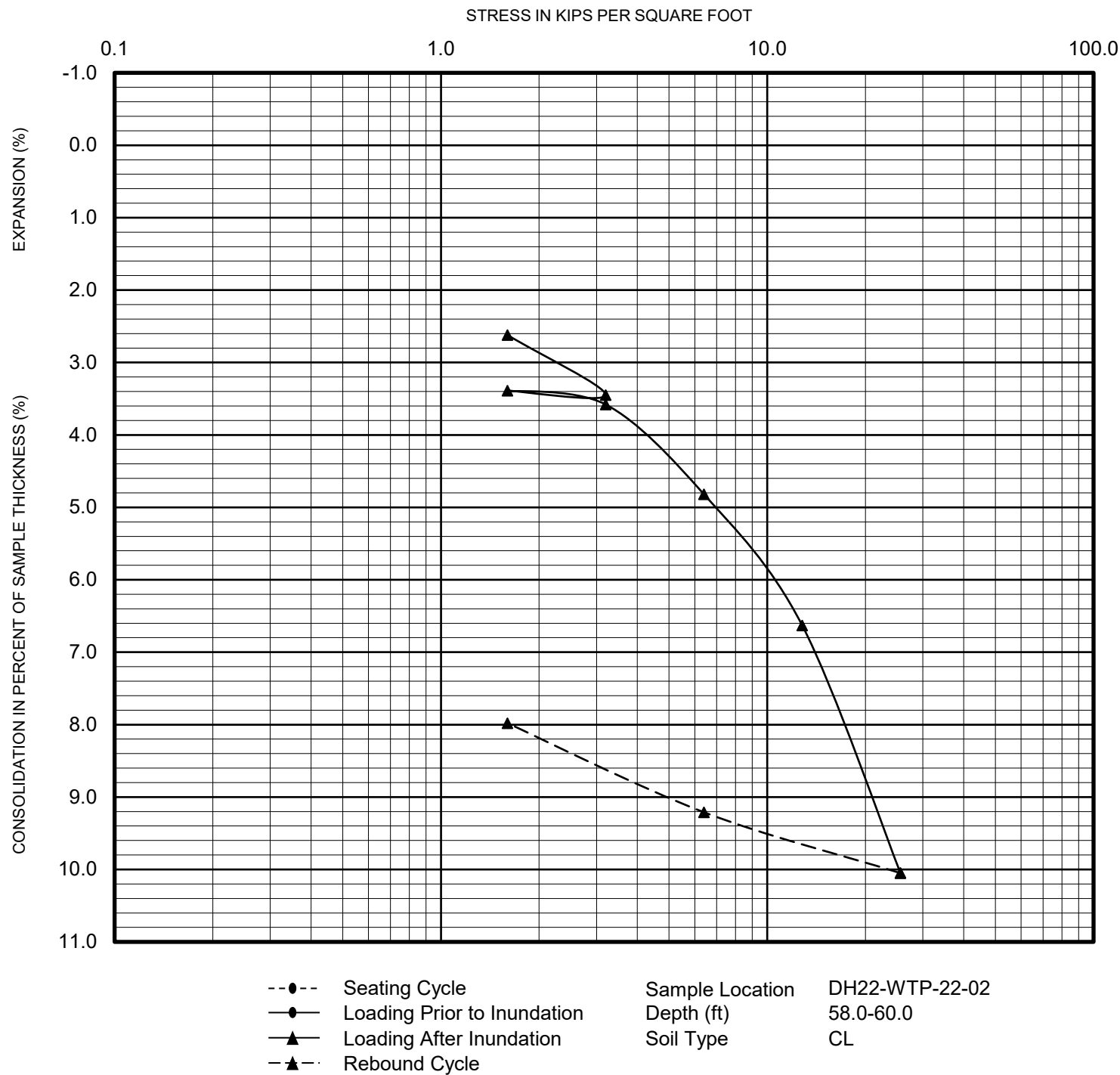


Sample Location DH22-WTP-02
Depth (ft) 37.0-39.0

Load (ksf) 6.4
Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-17



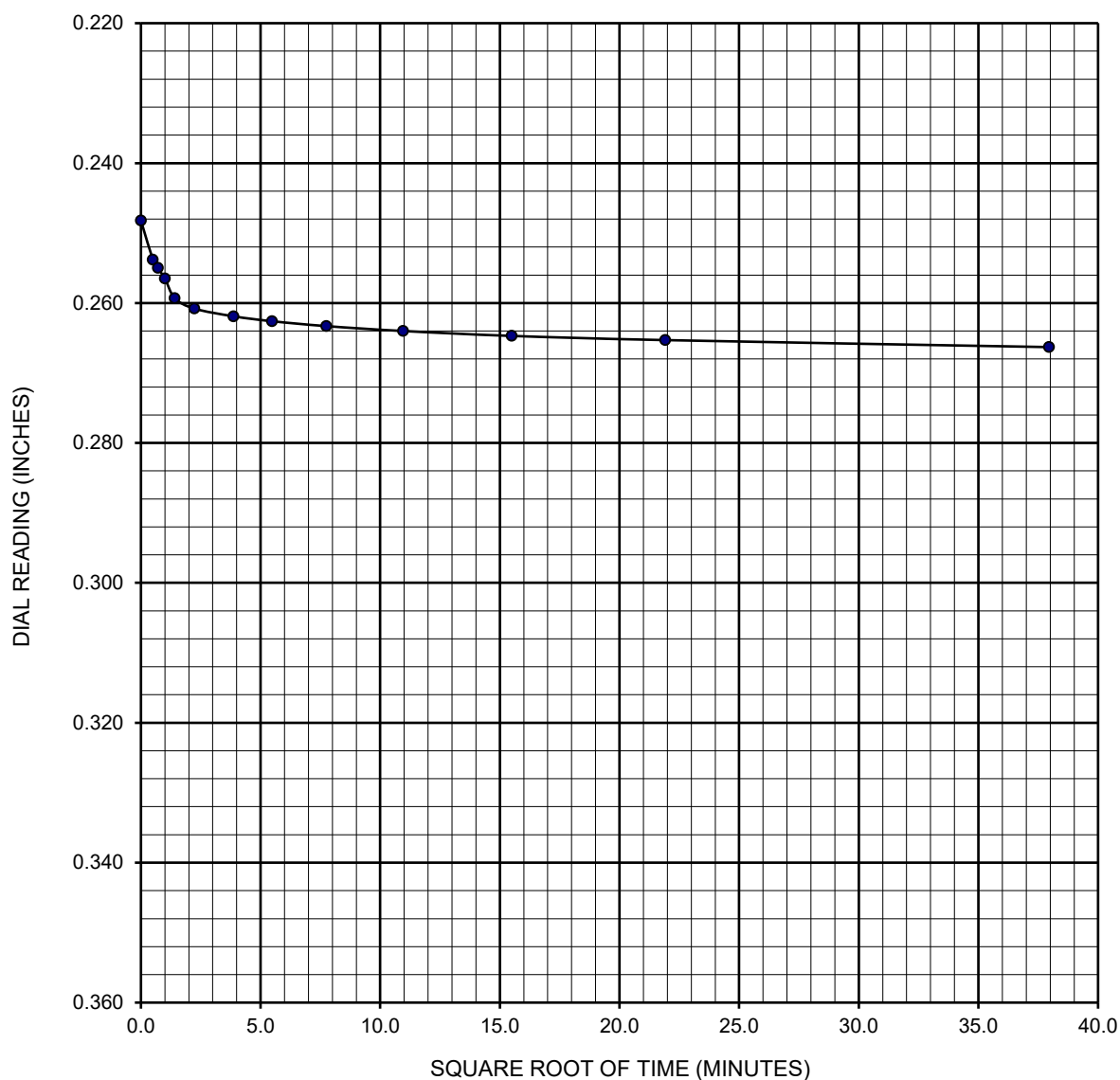
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-18

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22

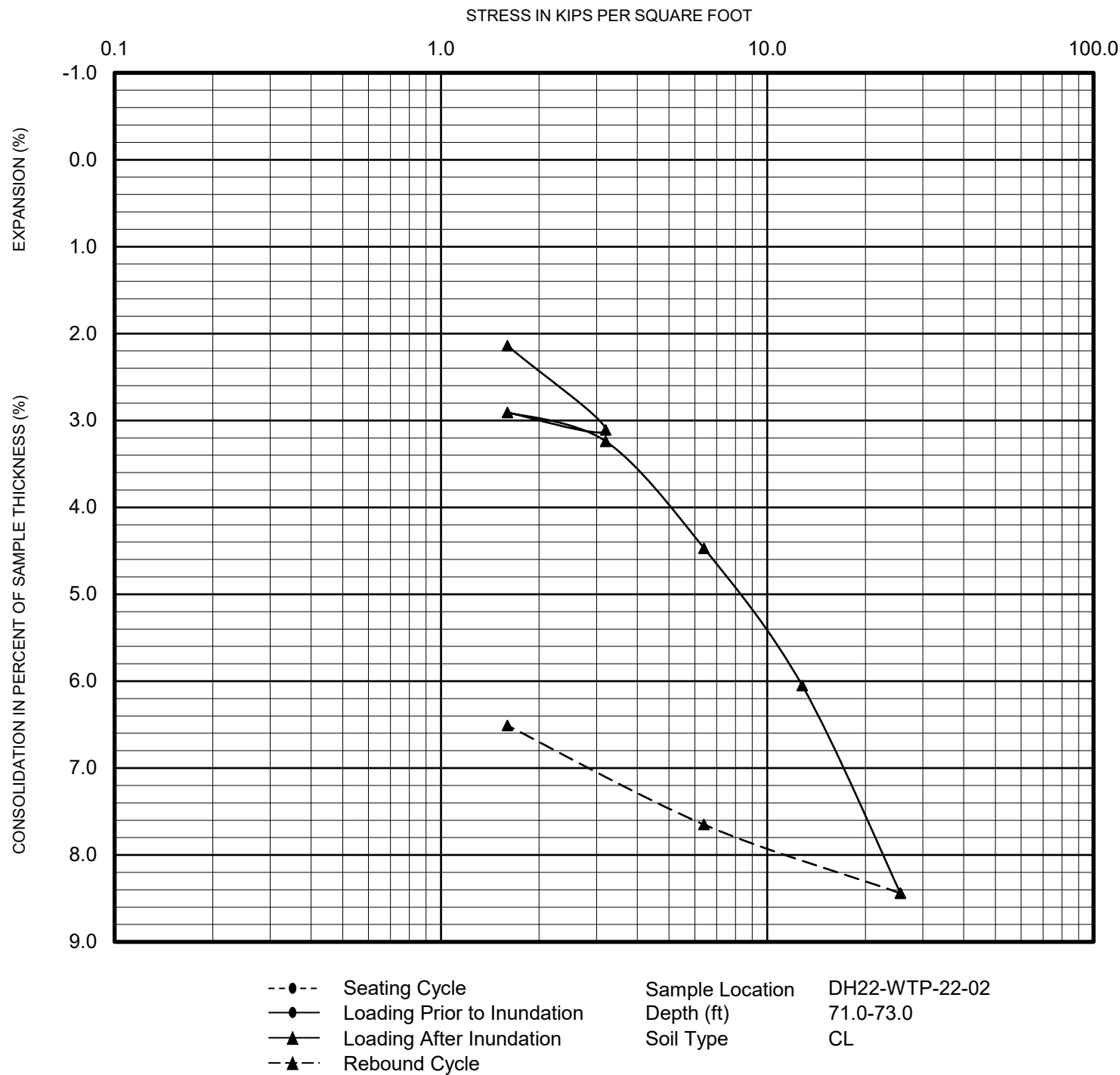


Sample Location DH22-WTP-02
Depth (ft) 58.0-60.0

Load (ksf) 12.8
Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-19



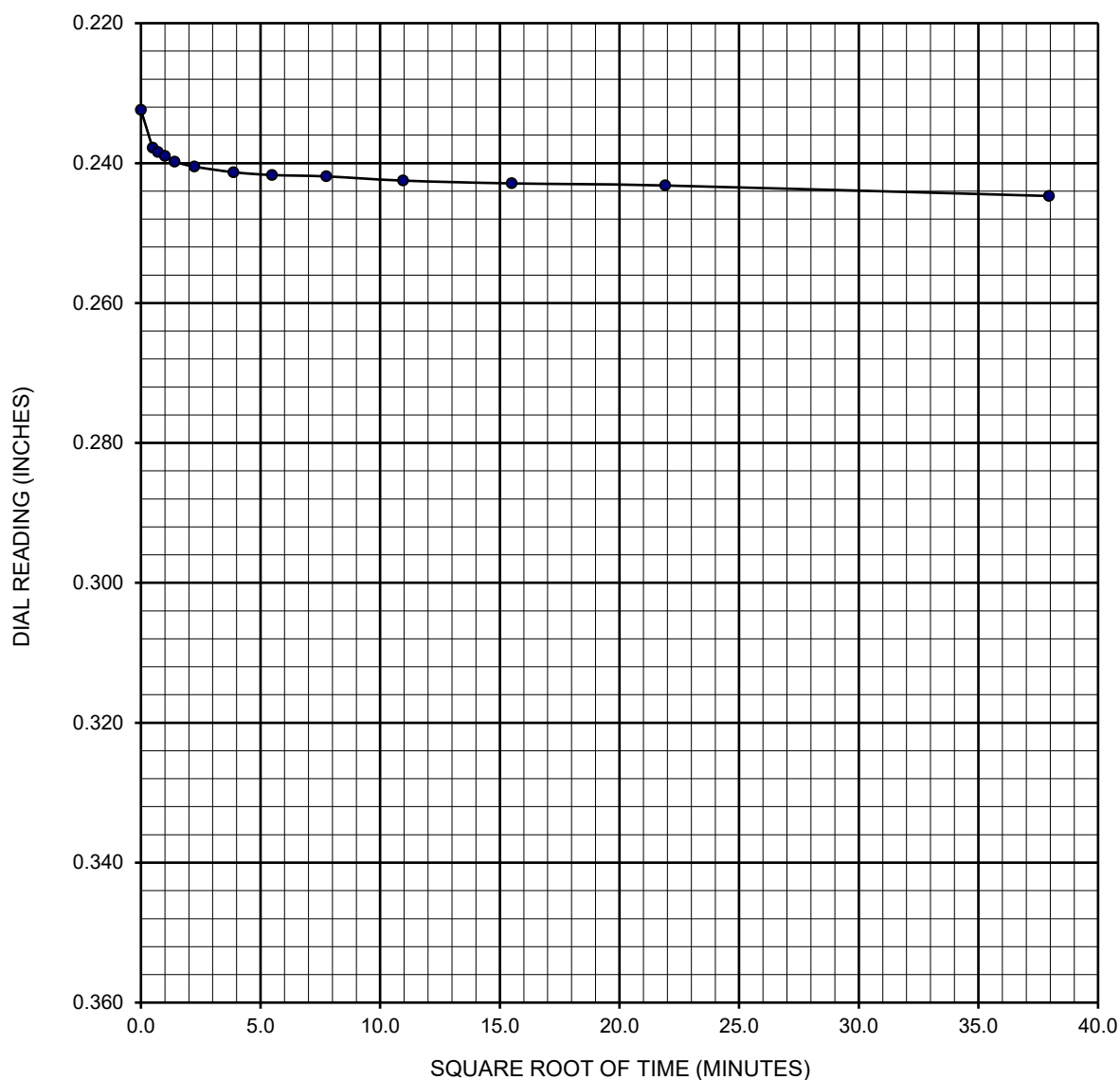
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-20

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22

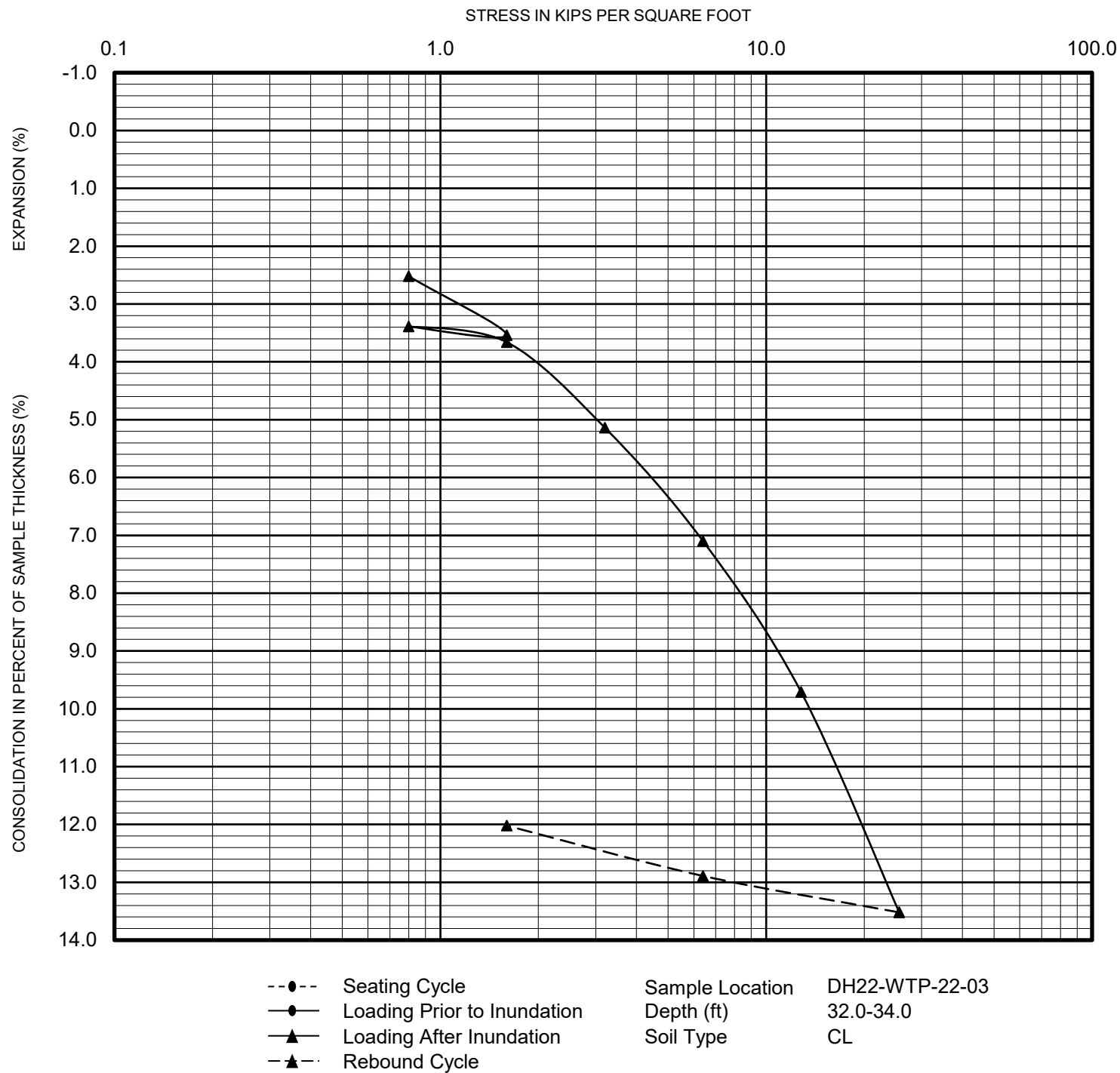


Sample Location DH22-WTP-02
Depth (ft) 58.0-60.0

Load (ksf) 6.4
Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-21



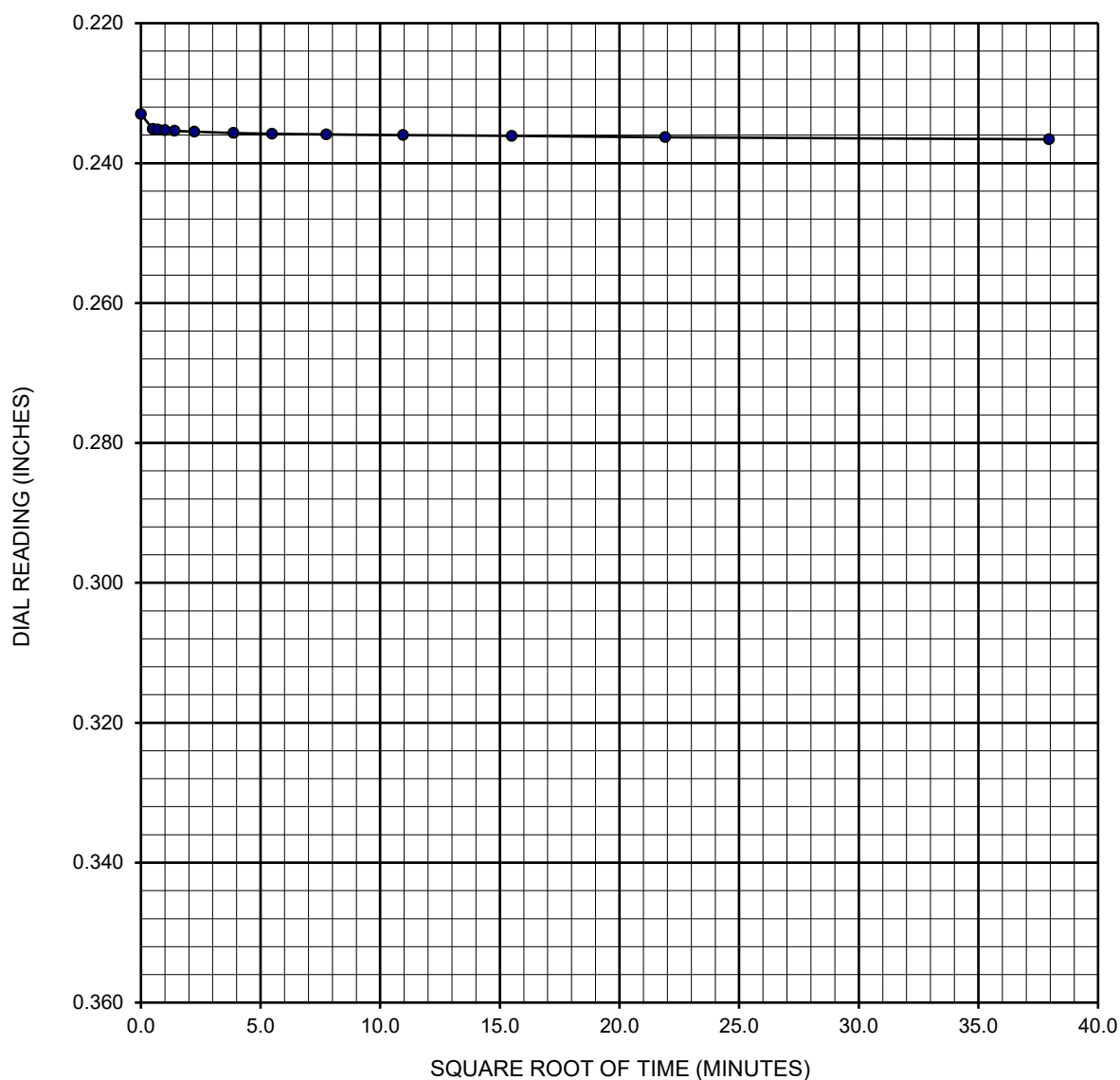
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-22

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22

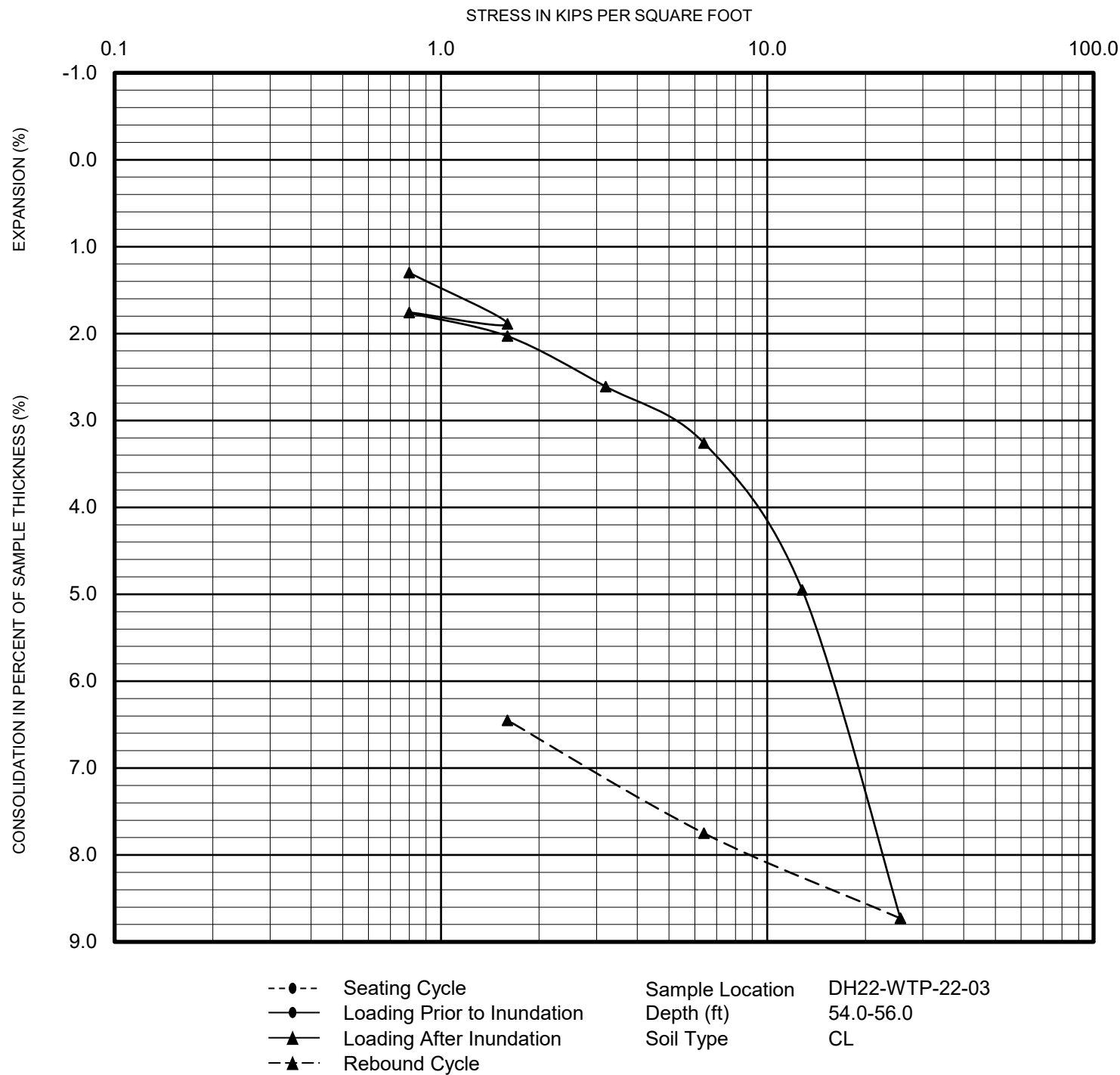


Sample Location DH22-WTP-03
Depth (ft) 32.0-34.0

Load (ksf) 1.6
Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-23



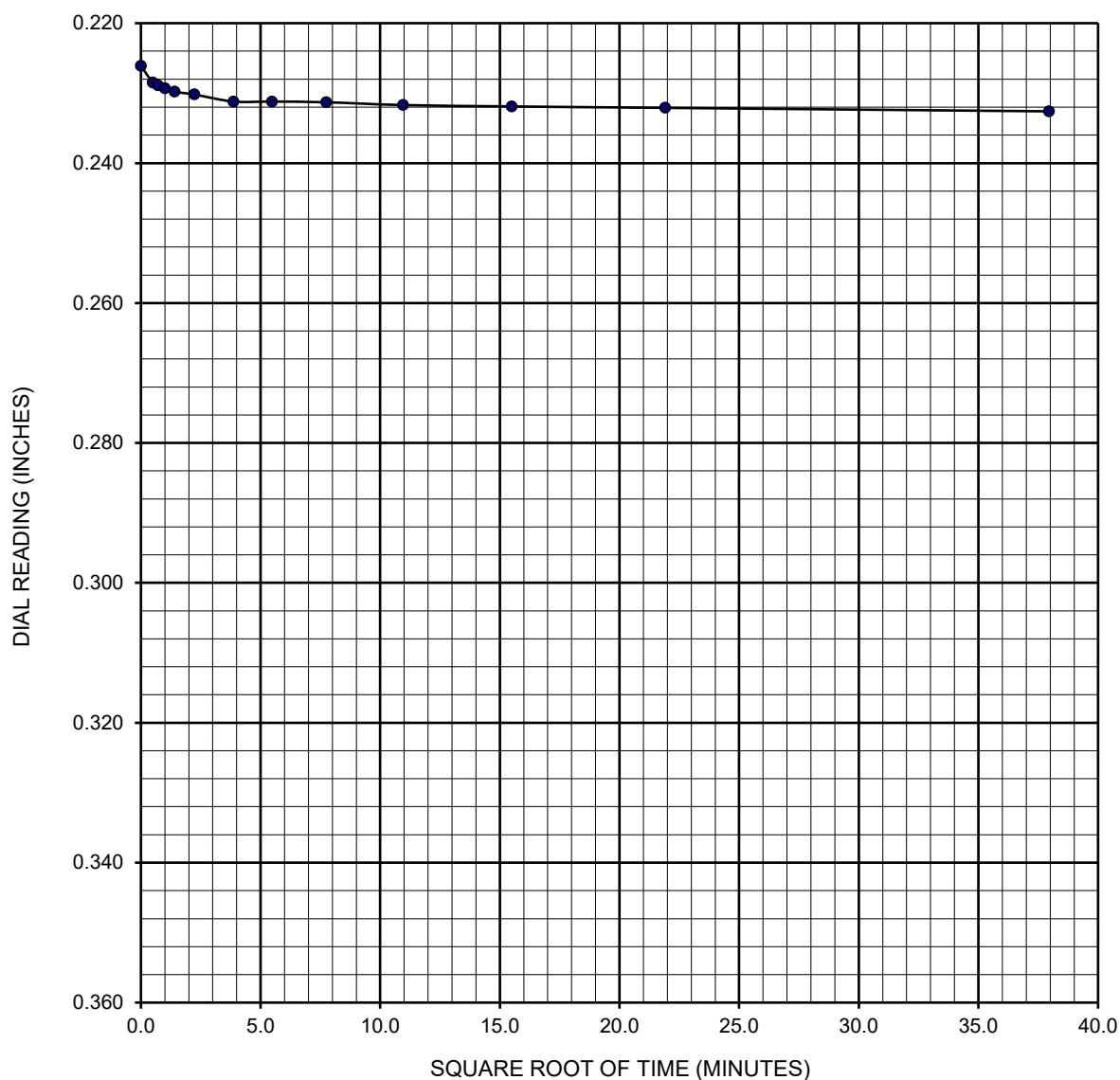
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-24

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22

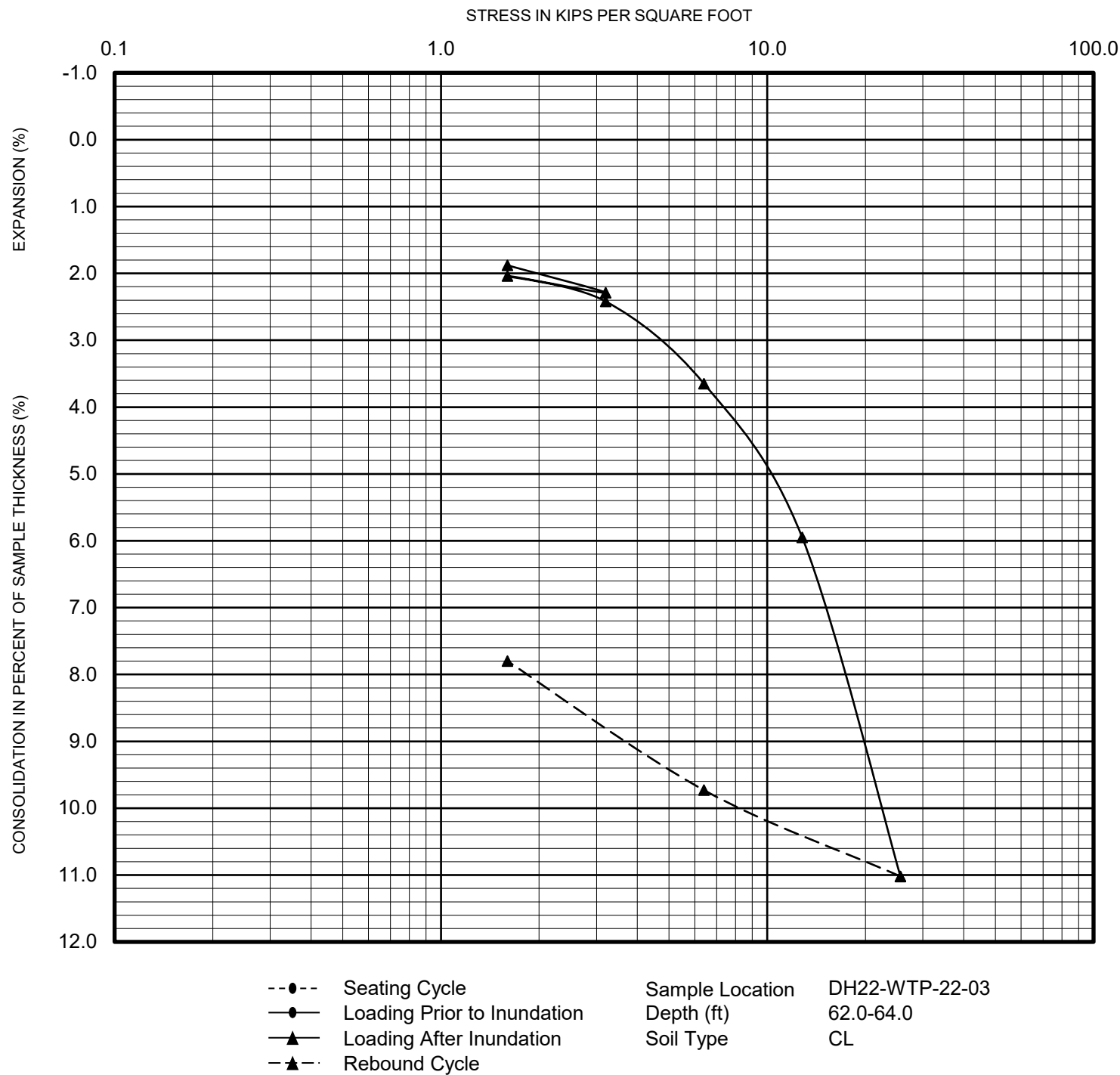


Sample Location DH22-WTP-03
Depth (ft) 54.0-56.0

Load (ksf) 6.4
Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-25



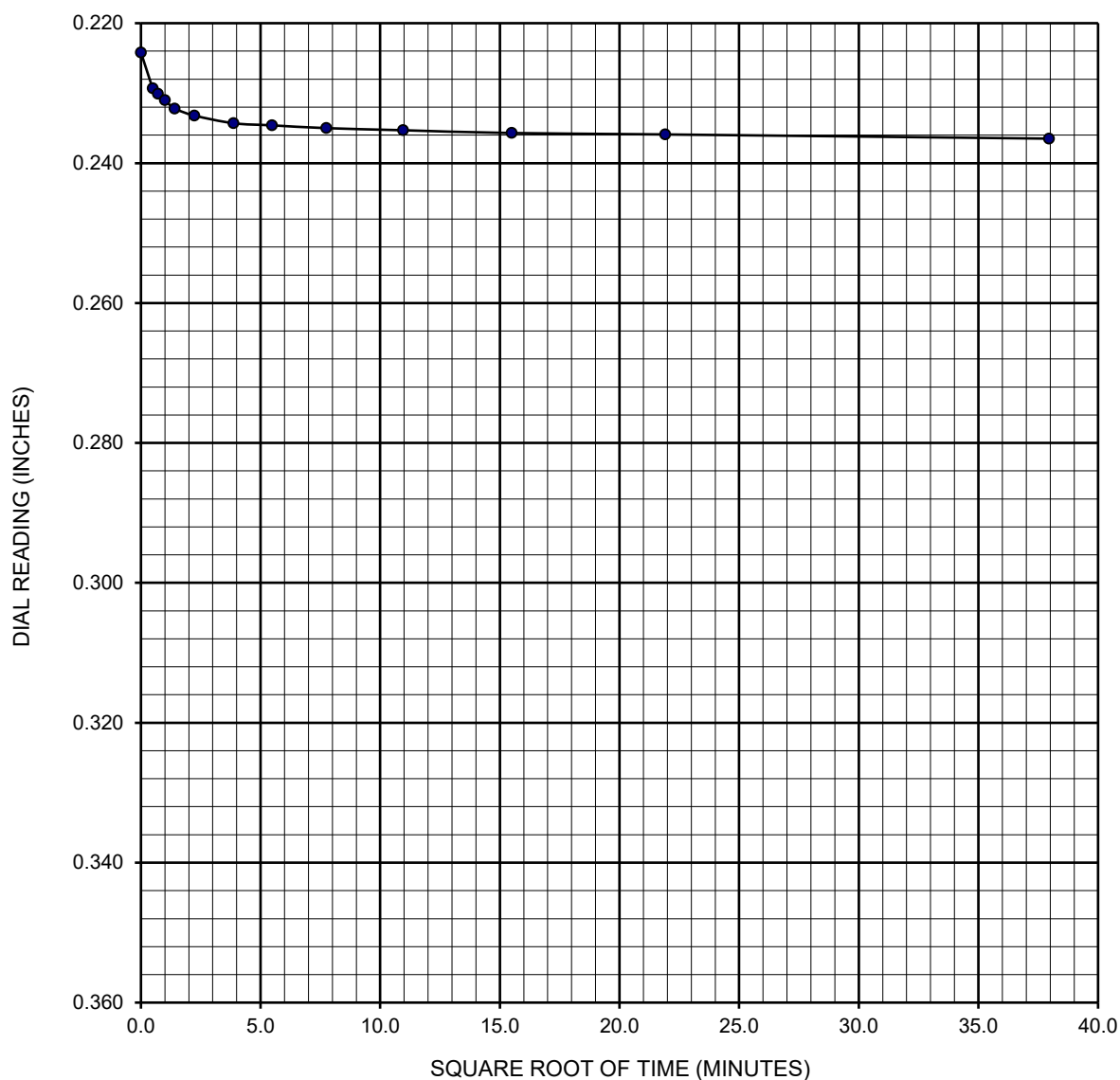
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435

FIGURE B-26

CONSOLIDATION TEST RESULTS

WATER TREATMENT PLANT
PROVO, UTAH

AECOM # 60670884 | 800179002 | 9/22



Sample Location DH22-WTP-03
 Depth (ft) 62.0-64.0

Load (ksf) 6.4
 Soil Type CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2435 - SQUARE ROOT OF TIME METHOD

FIGURE B-27

SAMPLE LOCATION	SAMPLE DEPTH (ft)	USCS SOIL TYPE	ORGANIC CONTENT (percent by dry weight)
DH22-P-03 / B-01	4.0 to 6.0	SM	28.5

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D2974

FIGURE B-26



MOISTURE TEST DATA (ASTM D2937)

Page No. **1 OF 2**

Project Name: Water Treatment Plant, Provo, Utah				Project No.: 800179001			Technician: RL		Date: 6/22		
Sample Location		DH22-P-01 / BK-01	DH22-P-01 / B-03	DH22-P-02 / BK-02	DH22-P-02 / B-04	DH22-P-02 / B-06	DH22-P-03 / B-01	DH22-P-03 / B-05	DH22-HDD-01 / SPT-04	DH22-HDD-01 / B-08	DH22-HDD-01 / B-11
Sample Depth (ft)		3.0-5.0	8.5-9.0	3.0-6.0	10.0-11.0	14.0-15.0	4.0-6.0	14.0-16.0	6.5-8.0	14.0-16.0	23.0-25.0
Visual Soil Classification	Top	--	--	--	--	--	--	--	--	--	--
	Bottom	--	--	--	--	--	--	--	--	--	--
Torvane Shear (tsf)		--	--	--	--	--	--	--	--	--	--
Pocket Penetrometer (tsf)		--	--	--	--	--	--	--	--	--	--
WEIGHTS	Weight of Moist Soil + Rings (g)	--	--	--	--	--	--	--	--	--	--
	Number of Rings	--	--	--	--	--	--	--	--	--	--
	Weight of Rings (g)	--	--	--	--	--	--	--	--	--	--
	Weight of Moist Soil (g)	--	--	--	--	--	--	--	--	--	--
	Dish Number	PAN 2	L0	X1	P0	S4	S41	Z23	PL6	PL7	S22
	Weight of Moist Soil + Tare (g)	3334.1	1852.9	1262.8	995.8	995.8	1859.3	1649.2	747.5	1013.7	972.8
	Weight of Dry Soil + Tare (g)	2962.6	1511.5	1122.9	889.4	888.7	1464.4	1600.8	704.2	922.1	868.2
	Weight of Tare (g)	618.8	601.5	413.7	409.6	398.1	394.9	398.3	395.3	396.1	398.0
RESULTS	Wet Density (pcf)	--	--	--	--	--	--	--	--	--	--
	Moisture Content (%)	15.9	37.5	19.7	22.2	21.8	36.9	4.0	14.0	17.4	22.2
	Dry Density (pcf)	--	--	--	--	--	--	--	--	--	--
	Degree of Saturation (%)	--	--	--	--	--	--	--	--	--	--
	Remarks	--	--	--	--	--	--	--	--	--	--



MOISTURE TEST DATA (ASTM D2937)

Page No. **2 OF 2**

Project Name: Water Treatment Plant, Provo, Utah					Project No.: 800179001		Technician: RL		Date: 6/22	
Sample Location		DH22-HDD-01 / B-17	DH22-WTP-01 / SPT-06	DH22-WTP-01 / SPT-10	DH22-WTP-01 / B-12	DH22-WTP-01 / SH-18	DH22-WTP-01 / SH-21	DH22-WTP-01 / B-24	DH22-WTP-01 / B-31	DH22-WTP-01 / SPT-33
Sample Depth (ft)		38.0-40.0	21.5-23.0	26.5-28.0	31.5-35.0	56.5-58.5	66.5-68.5	74.0-76.0	98.0-100.0	106.5-108.0
Visual Soil Classification	Top	--	--	--	--	--	--	--	--	--
	Bottom	--	--	--	--	--	--	--	--	--
Torvane Shear (tsf)		--	--	--	--	--	--	--	--	--
Pocket Penetrometer (tsf)		--	--	--	--	--	--	--	--	--
WEIGHTS	Weight of Moist Soil + Rings (g)	--	--	--	--	--	--	--	--	--
	Number of Rings	--	--	--	--	--	--	--	--	--
	Weight of Rings (g)	--	--	--	--	--	--	--	--	--
	Weight of Moist Soil (g)	--	--	--	--	--	--	--	--	--
	Dish Number	ML	S3	XT	X5	B67	S44	SM	B66	GM
	Weight of Moist Soil + Tare (g)	1478.4	717.2	779.5	804.1	730.3	981.7	1006.5	992.0	1020.3
	Weight of Dry Soil + Tare (g)	1456.7	661.3	714.7	713.9	667.0	829.4	982.9	861.7	905.3
	Weight of Tare (g)	396.7	396.5	394.1	378.4	394.4	401.4	395.4	390.0	392.2
RESULTS	Wet Density (pcf)	--	--	--	--	--	--	--	--	--
	Moisture Content (%)	2.0	21.1	20.2	26.9	23.2	35.6	4.0	27.6	22.4
	Dry Density (pcf)	--	--	--	--	--	--	--	--	--
	Degree of Saturation (%)	--	--	--	--	--	--	--	--	--
	Remarks	--	--	--	--	--	--	--	--	--



MOISTURE TEST DATA (ASTM D2488)

Page No. **1**

Project Name: Water Treatment Plant, Provo, Utah				Project No.: 60670884/800179002		Technician: NW		Date: 9/22	
Sample Location		DH-22-WTP-02 MC-01	DH-22-WTP-02 SPT-10B	DH-22-WTP-02 SPT-13	DH-22-WTP-02 SPT-14	DH-22-WTP-03 SPT-13A			
Sample Depth (ft)		20.0-22.0	32.8-34.0	45.0-47.0	47.0-49.0	44.0-45.0			
Visual Soil Classification	Top	--	--	--	--	--			
	Bottom	--	--	--	--	--			
Torvane Shear (tsf)		--	--	--	--	--			
Pocket Penetrometer (tsf)		--	--	--	--	--			
WEIGHTS	Weight of Moist Soil + Rings (g)	--	--	--	--	--			
	Number of Rings	--	--	--	--	--			
	Weight of Rings (g)	--	--	--	--	--			
	Weight of Moist Soil (g)	--	--	--	--	--			
	Dish Number	184	VAL	XT	BOY	H2			
	Weight of Moist Soil + Tare (g)	1987.1	782.8	782.3	838.4	546.2			
	Weight of Dry Soil + Tare (g)	1675.9	696.9	705.0	745.2	504.0			
	Weight of Tare (g)	417.1	379.1	395.0	398.1	330.3			
RESULTS	Wet Density (pcf)	--	--	--	--	--			
	Moisture Content (%)	24.7	27.0	24.9	26.9	24.3			
	Dry Density (pcf)	--	--	--	--	--			
	Degree of Saturation (%)	--	--	--	--	--			
	Remarks								



MOISTURE - DENSITY TEST DATA (ASTM D2216)

Page No. **1**

Project Name: Water Treatment Plant, Provo, Utah					Project No.: 60670884/800179002		Technician: NMV		Date: 9/22	
Sample Location		DH22-WTP-02 SH-02	DH22-WTP-02 SH-02	DH22-WTP-03 SH-01	DH22-WTP-03 SH-01	DH22-WTP-03 SH-02	DH22-WTP-03 SH-02			
Sample Depth (ft)		37.0-39.0	37.0-39.0	32.0-34.0	32.0-34.0	54.0-56.0	54.0-56.0			
Visual Soil Classification	Top	SC	SC	--	--	--	--			
	Bottom	SC	SC	--	--	--	--			
Torvane Shear (tsf)		--	--	--	--	--	--			
Pocket Penetrometer (tsf)		--	--	--	--	--	--			
WEIGHTS	Weight of Moist Soil + Rings (g)	188.8	187.5	189.3	183.1	185.2	181.8			
	Number of Rings	1	1	1	1	1	1			
	Weight of Rings (g)	37.5	37.5	42.4	42.4	38.3	38.3			
	Weight of Moist Soil (g)	151.3	150	146.9	140.7	146.9	143.5			
	Dish Number	--	--	--	--	--	--			
	Weight of Moist Soil + Tare (g)	188.8	187.5	189.3	183.1	185.2	181.8			
	Weight of Dry Soil + Tare (g)	155.6	155.6	156.2	156.2	152.2	152.2			
	Weight of Tare (g)	37.5	37.5	42.4	42.4	38.3	38.3			
RESULTS	Wet Density (pcf)	125.3	124.2	121.7	116.5	121.7	118.9			
	Moisture Content (%)	28.1	27.0	29.1	23.6	29.0	26.0			
	Dry Density (pcf)	97.8	97.8	94.3	94.2	94.3	94.3			
	Degree of Saturation (%)	107.8	103.6	102.3	82.9	101.9	91.4			
	Remarks	Before Consolidation	After Consolidation	Before Consolidation	After Consolidation	Before Consolidation	After Consolidation			



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Certificate of Analysis

Ninyo and Moore
Joseph Spendlove
871 Robinson Drive
North Salt Lake, UT 84054

PO#: 800179001
Receipt: 4/11/22 17:00 @ 22.3 °C
Date Reported: 4/21/2022
Project Name: 800179001

Sample ID: DH22-P-01 B-03

Matrix: Solid

Lab ID: 22D0747-01

Date Sampled: 4/5/22 8:30

Sampled By: Joseph Spendlove

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	431	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
eH	453	mV	0.1	SM 2580 B	4/12/22 10:46	4/12/22 12:13	SPH
pH	8.6	pH Units	0.1	EPA 9045D	4/12/22	4/12/22	
Sulfate, Soluble (IC)	19	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
Total Dissolved Solids (TDS)	11400	mg/L	200	SM 2540 C	4/12/22	4/14/22	
Total Solids	86.4	%	0.1	SM 2540G	4/11/22	4/11/22	
Resistivity	6.1	ohm m	1.0	SSSA 10-3.3	4/12/22	4/12/22	
Metals							
Sodium, Total	662	mg/kg dry	254	EPA 6010B/C/D	4/13/22	4/15/22	



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PO#: 800179001
Receipt: 4/11/22 17:00 @ 22.3 °C
Date Reported: 4/21/2022
Project Name: 800179001

Sample ID: DH22-P-03 B-05

Matrix: Solid

Lab ID: 22D0747-02

Date Sampled: 4/6/22 8:30

Sampled By: Joseph Spendlove

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	28	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
eH	391	mV	0.1	SM 2580 B	4/12/22 10:46	4/12/22 12:13	SPH
pH	8.4	pH Units	0.1	EPA 9045D	4/12/22	4/12/22	
Sulfate, Soluble (IC)	16	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
Total Dissolved Solids (TDS)	2200	mg/L	200	SM 2540 C	4/12/22	4/14/22	
Total Solids	92.5	%	0.1	SM 2540G	4/11/22	4/11/22	
Resistivity	19.3	ohm m	1.0	SSSA 10-3.3	4/12/22	4/12/22	
Metals							
Sodium, Total	191	mg/kg dry	30.5	EPA 6010B/C/D	4/13/22	4/18/22	



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PO#: 800179001
Receipt: 4/11/22 17:00 @ 22.3 °C
Date Reported: 4/21/2022
Project Name: 800179001

Sample ID: DH22-P-02 BK-02

Matrix: Solid

Lab ID: 22D0747-03

Comment: Collection date not provided - sample may or may not be within hold

Date Sampled: 4/11/22 0:00

Sampled By: Joseph Spendlove

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	14	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
eH	464	mV	0.1	SM 2580 B	4/12/22 10:46	4/12/22 12:13	SPH
pH	8.6	pH Units	0.1	EPA 9045D	4/12/22	4/12/22	
Sulfate, Soluble (IC)	25	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
Total Dissolved Solids (TDS)	28400	mg/L	200	SM 2540 C	4/12/22	4/14/22	
Total Solids	83.5	%	0.1	SM 2540G	4/11/22	4/11/22	
Resistivity	16.6	ohm m	1.0	SSSA 10-3.3	4/12/22	4/12/22	
Metals							
Sodium, Total	211	mg/kg dry	63.3	EPA 6010B/C/D	4/13/22	4/18/22	



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Receipt: 4/11/22 17:00 @ 22.3 °C
Date Reported: 4/21/2022
Project Name: 800179001

Sample ID: DH22-P-03 B-01

Matrix: Solid

Lab ID: 22D0747-04

Comment: Collection date not provided - sample may or may not be within hold

Date Sampled: 4/11/22 0:00

Sampled By: Joseph Spendlove

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	36	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
eH	393	mV	0.1	SM 2580 B	4/12/22 10:46	4/12/22 12:13	SPH
pH	8.1	pH Units	0.1	EPA 9045D	4/12/22	4/12/22	
Sulfate, Soluble (IC)	379	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
Total Dissolved Solids (TDS)	5900	mg/L	200	SM 2540 C	4/12/22	4/14/22	
Total Solids	78.5	%	0.1	SM 2540G	4/11/22	4/11/22	
Resistivity	8.9	ohm m	1.0	SSSA 10-3.3	4/12/22	4/12/22	
Metals							
Sodium, Total	166	mg/kg dry	32.1	EPA 6010B/C/D	4/13/22	4/18/22	



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PO#: 800179001
Receipt: 4/11/22 17:00 @ 22.3 °C
Date Reported: 4/21/2022
Project Name: 800179001

Sample ID: DH22-HDD-01 B-08

Matrix: Solid

Lab ID: 22D0747-05

Comment: Collection date not provided - sample may or may not be within hold

Date Sampled: 4/11/22 0:00

Sampled By: Joseph Spendlove

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	10	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
eH	392	mV	0.1	SM 2580 B	4/12/22 10:46	4/12/22 12:13	SPH
pH	8.8	pH Units	0.1	EPA 9045D	4/12/22	4/12/22	
Sulfate, Soluble (IC)	43	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
Total Dissolved Solids (TDS)	10600	mg/L	200	SM 2540 C	4/12/22	4/14/22	
Total Solids	84.6	%	0.1	SM 2540G	4/11/22	4/11/22	
Resistivity	17.9	ohm m	1.0	SSSA 10-3.3	4/12/22	4/12/22	
Metals							
Sodium, Total	99.4	mg/kg dry	23.4	EPA 6010B/C/D	4/13/22	4/18/22	



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PO#: 800179001
Receipt: 4/11/22 17:00 @ 22.3 °C
Date Reported: 4/21/2022
Project Name: 800179001

Sample ID: DH22-WTP-01 B-02

Matrix: Solid

Lab ID: 22D0747-06

Comment: Collection date not provided - sample may or may not be within hold

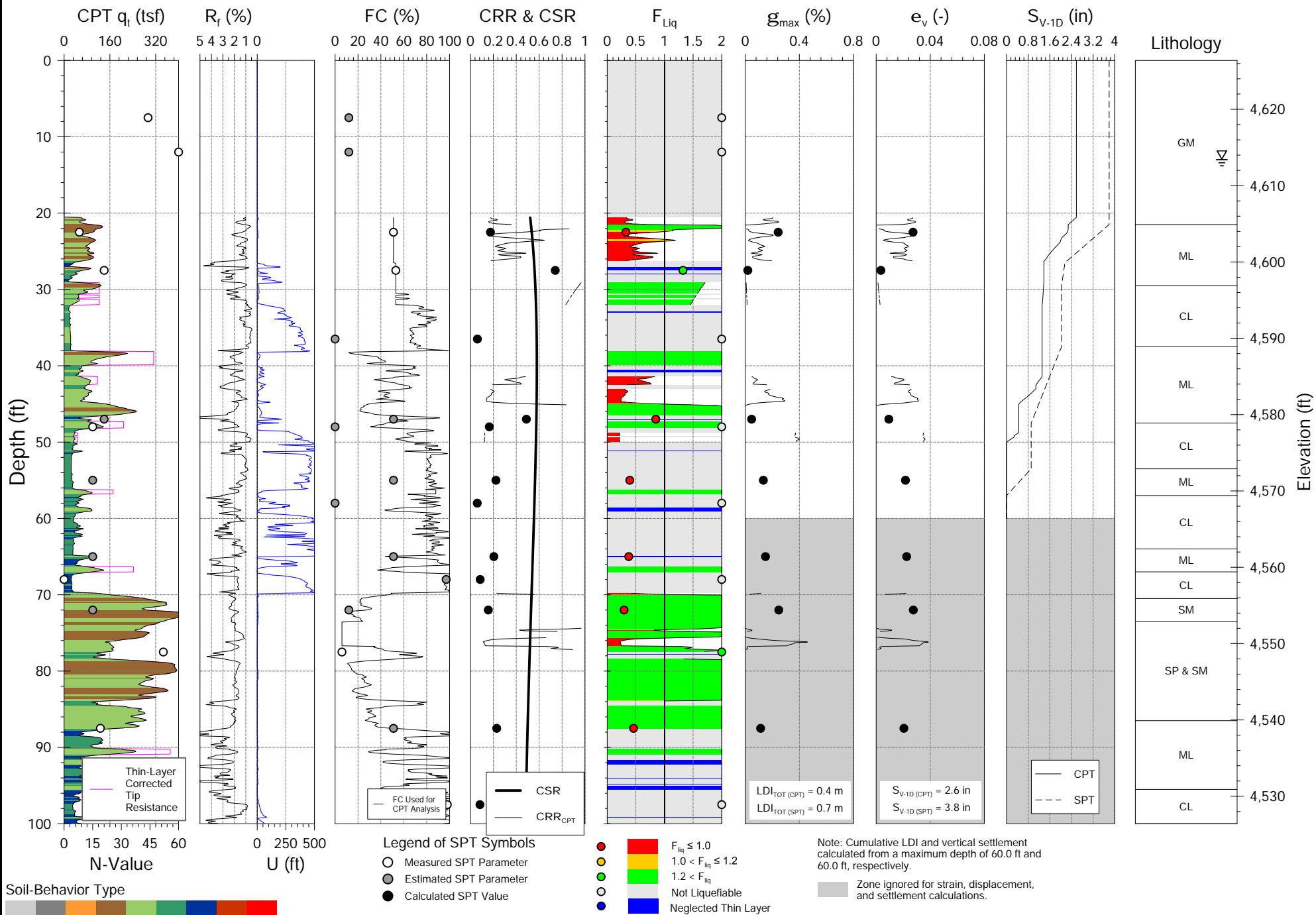
Date Sampled: 4/11/22 0:00

Sampled By: Joseph Spendlove

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	44	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
eH	368	mV	0.1	SM 2580 B	4/12/22 10:46	4/12/22 12:13	SPH
pH	9.5	pH Units	0.1	EPA 9045D	4/12/22	4/12/22	
Sulfate, Soluble (IC)	12	mg/kg dry	3	EPA 300.0	4/14/22	4/14/22	
Total Dissolved Solids (TDS)	2500	mg/L	200	SM 2540 C	4/12/22	4/14/22	
Total Solids	93.8	%	0.1	SM 2540G	4/11/22	4/11/22	
Resistivity	16.7	ohm m	1.0	SSSA 10-3.3	4/12/22	4/12/22	
Metals							
Sodium, Total	206	mg/kg dry	197	EPA 6010B/C/D	4/13/22	4/15/22	

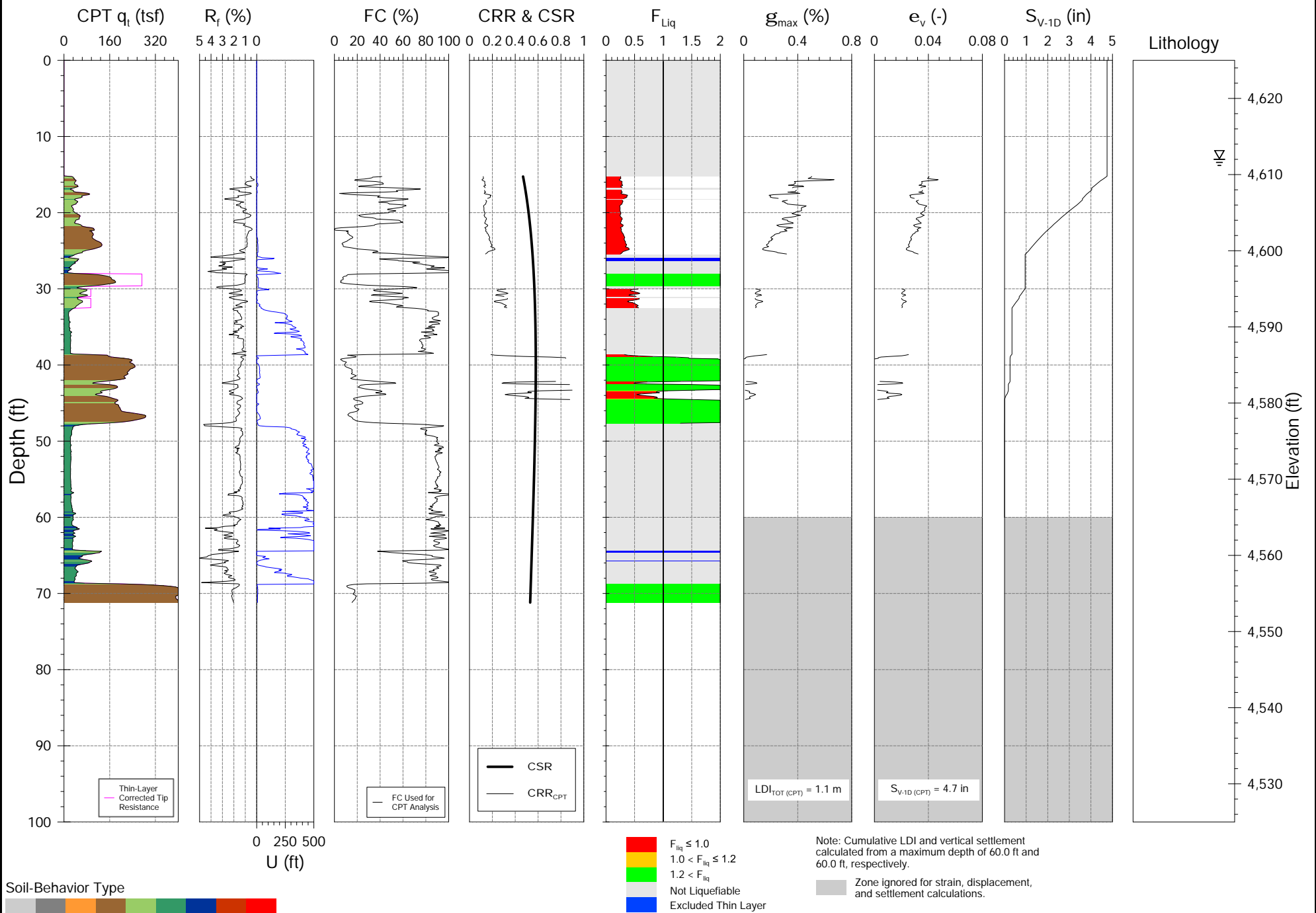
Appendix E Liquefaction Analysis Results

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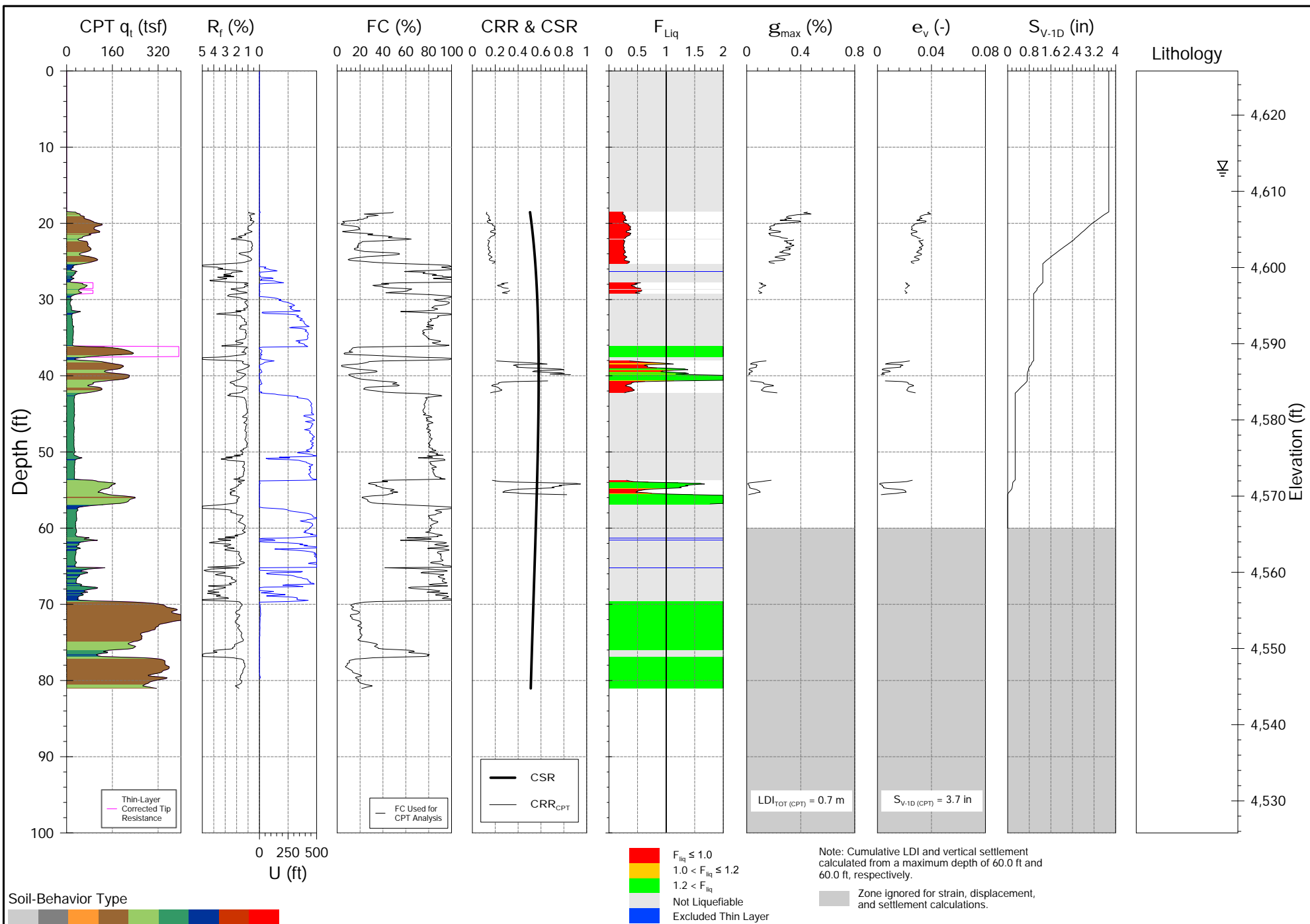
PROJECT NO. 60670884	PROVO CITY HANSEN, ALLEN & LUCE	PROVO WATER TREATMENT PLANT DH22-WTP-01 & CP22-WTP-01	FIGURE 1
AECOM	PROVO, UT		

C:\Users\Benjamin.Barrett\OneDrive - AECOM\Documents - 60670884 - Provo WTP Geotech\General\Calculations\Liquefaction\CP22-WTP-04\CPT Liquefaction Figure.grf 09/08/2022 10:03:12



Peak Ground Acceleration, PGA = 0.697g
Earthquake Magnitude, M = 7.09
Ground Motion: 2475-year based on ASCE/SEI 7-16
Method: Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT Based Liquefaction Triggering Procedures (Report No. UCDC/GM-14/01)

PROJECT NO. 60670884	PROVO CITY HANSEN, ALLEN & LUCE	PROVO WATER TREATMENT PLANT CP22-WTP-04	FIGURE 4
AECOM	PROVO, UT		



PROJECT NO.
60670884

AECOM

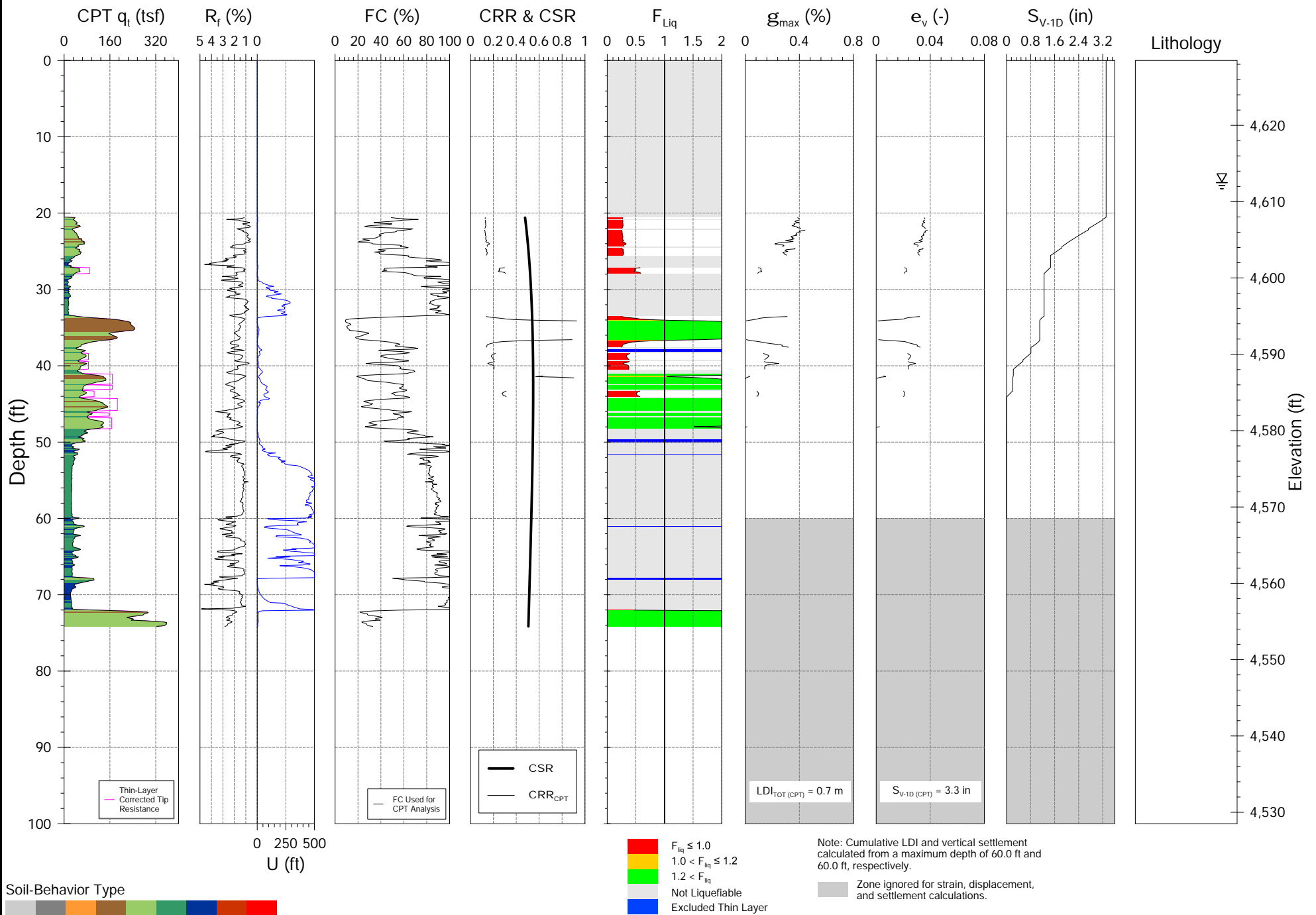
PROVO CITY
HANSEN, ALLEN & LUCE

PROVO, UT

PROVO WATER TREATMENT PLANT
CP22-WTP-05

FIGURE
5

C:\Users\Benjamin.Barrett\OneDrive - AECOM\Documents - 60670884 - Provo WTP Geotech\General\Calculations\Liquefaction\CP22-WTP-06\CPT Liquefaction Figure.grf 09/09/2022 11:17:20



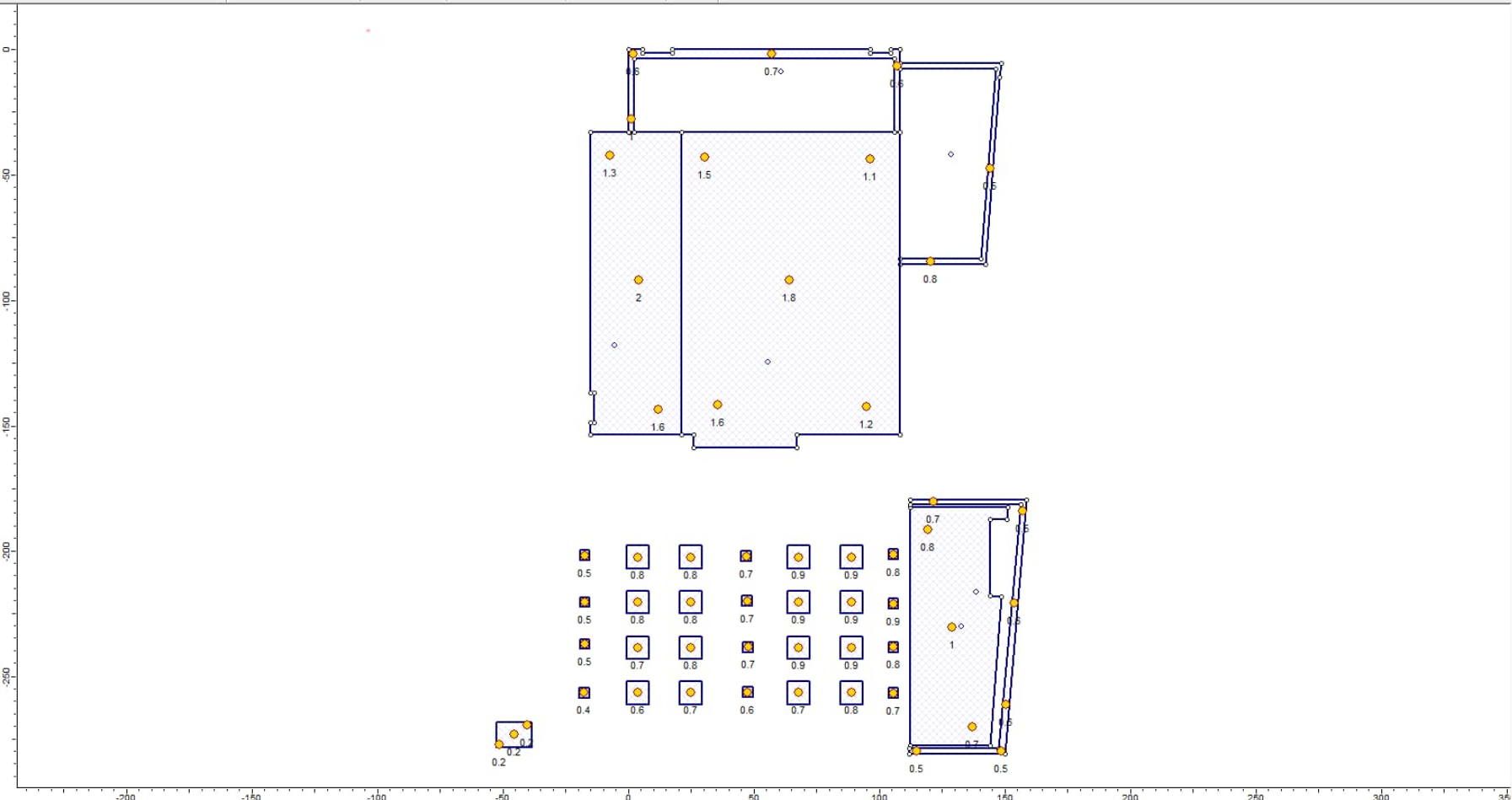
Soil-Behavior Type

Very Stiff Gravel & Sand Silt & Clay Organic & Sensitive

Peak Ground Acceleration, PGA = 0.697g
Earthquake Magnitude, M = 7.09
Ground Motion: 2475-year based on ASCE/SEI 7-16
Method: Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT Based Liquefaction Triggering Procedures (Report No. UCDC/GM-14/01)

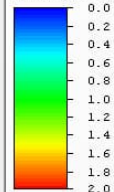
PROJECT NO. 60670884	PROVO CITY HANSEN, ALLEN & LUCE	PROVO WATER TREATMENT PLANT CP22-WTP-06	FIGURE 6
AECOM	PROVO, UT		

Appendix F Bearing Capacity and Settlement Analysis Results



Contour Legend

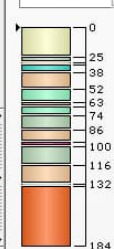
Total Settlement (in)



max (stage): 1.96 in
max (all): 1.96 in

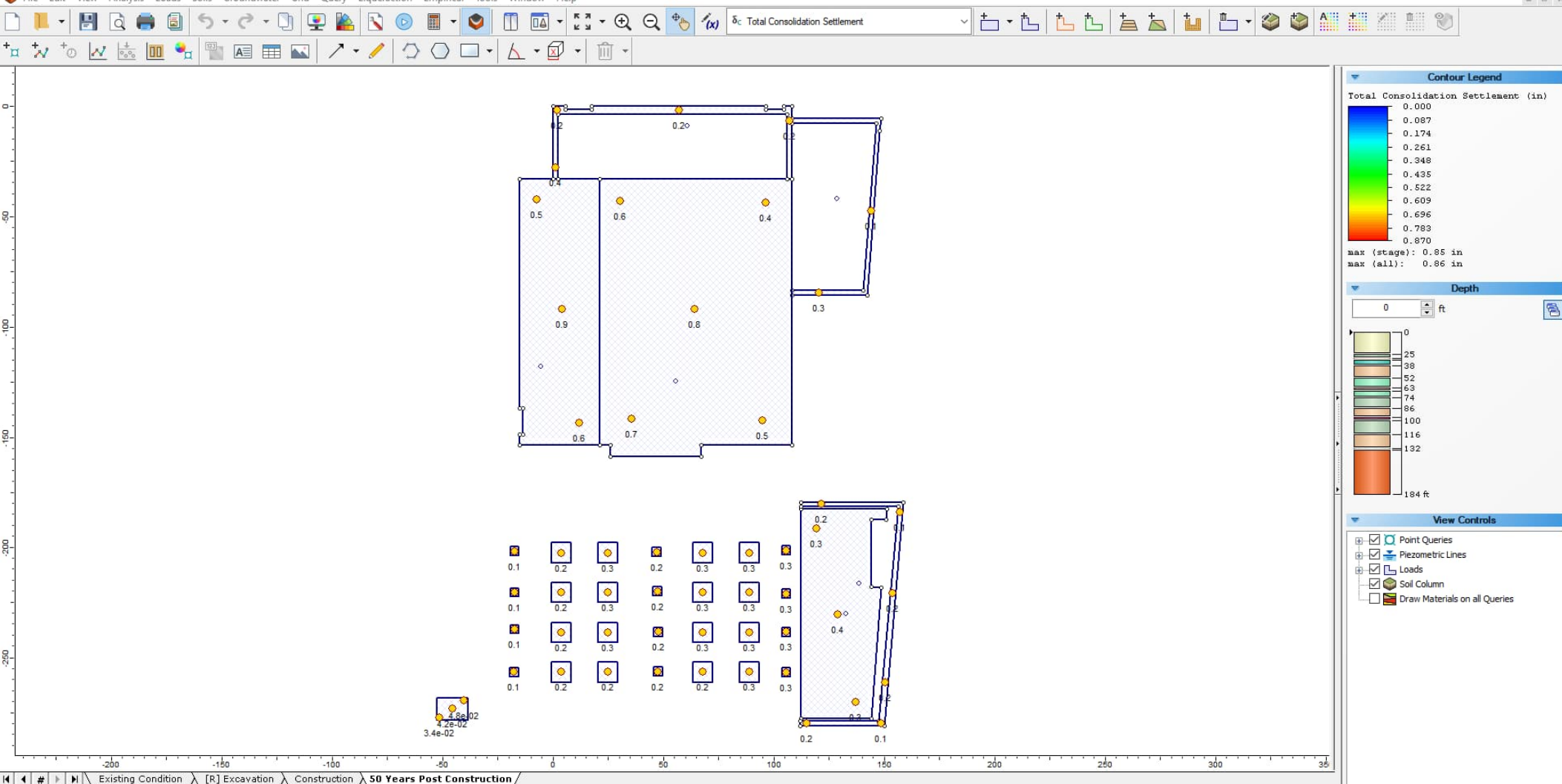
Depth

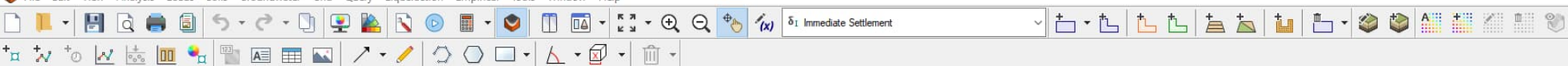
0 ft



View Controls

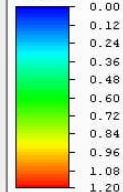
- ☒ Point Queries
- ☒ Piezometric Lines
- ☒ Loads
- ☒ Soil Column
- ☐ Draw Materials on all Queries





Contour Legend

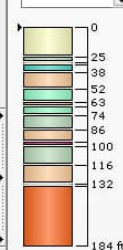
Immediate Settlement (in)



max (stage): 1.11 in
max (all): 1.11 in

Depth

0 ft



View Controls

- ☒ Point Queries
- ☒ Piezometric Lines
- ☒ Loads
- ☒ Soil Column
- ☐ Draw Materials on all Queries

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Settle3 Analysis Information

ProvoWTP_Settlement Analysis

Project Settings

Document Name	ProvoWTP_Settlement Analysis.s3z
Date Created	4/25/2022, 3:37:37 PM
Last saved with Settle3 version	5.015
Stress Computation Method	Boussinesq
Stress Units	Imperial, stress as ksf
Settlement Units	inches

Advanced Settings

Start of secondary consolidation (% of primary)	95
Min. stress for secondary consolidation (% of initial)	1
Reset time when load changes for secondary consolidation	No
Minimum settlement ratio for subgrade modulus	0.9
Use average poisson's ratio to calculate layered stresses	
Ignore negative effective stresses in settlement calculations	
Add field points to load edges	

Soil Profile

Layer Option	Horizontal Soil Layers
Vertical Axis	Depth below ground surface

Stage Settings

Stage #	Name
1	Existing Condition
2	Excavation
3	Construction
4	50 Years Post Construction

Results (relative to Stage: Excavation)

Time taken to compute: 0 seconds

Stage: Existing Condition

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.90243
Total Consolidation Settlement [in]	0	0.861833
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0.861833
Immediate Settlement [in]	0	1.0406
Loading Stress ZZ [ksf]	-0.000409092	2.04039
Loading Stress XX [ksf]	-0.270517	1.7713
Loading Stress YY [ksf]	-0.480066	1.27796
Effective Stress ZZ [ksf]	-0.000409092	2.04039
Effective Stress XX [ksf]	-0.270517	1.7713
Effective Stress YY [ksf]	-0.480066	1.27796
Total Stress ZZ [ksf]	-0.000409092	2.04039
Total Stress XX [ksf]	-0.270517	1.7713
Total Stress YY [ksf]	-0.480066	1.27796
Modulus of Subgrade Reaction (Total) [ksf/ft]	-101.507	0.007969
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-137.396	0.0139768
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-454.258	0.0185395
Total Strain	-7.10228e-08	0.00476012
Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	-100	0
Pre-consolidation Stress [ksf]	-0.000198864	0
Over-consolidation Ratio	-196.21	0
Void Ratio	-0.0102024	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	-1.63622e-05	9.07475e-07

Stage: Excavation

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	0
Effective Stress XX [ksf]	0	0
Effective Stress YY [ksf]	0	0
Total Stress ZZ [ksf]	0	0
Total Stress XX [ksf]	0	0
Total Stress YY [ksf]	0	0
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0	0
Over-consolidation Ratio	0	0
Void Ratio	0	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0

Stage: Construction

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.96203
Total Consolidation Settlement [in]	0	0.851145
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0.851145
Immediate Settlement [in]	0	1.11089
Loading Stress ZZ [ksf]	0	4.00852
Loading Stress XX [ksf]	-0.206463	3.96986
Loading Stress YY [ksf]	-0.234475	4.00264
Effective Stress ZZ [ksf]	0	4.00852
Effective Stress XX [ksf]	-0.206463	3.96986
Effective Stress YY [ksf]	-0.234475	4.00264
Total Stress ZZ [ksf]	0	4.00852
Total Stress XX [ksf]	-0.206463	3.96986
Total Stress YY [ksf]	-0.234475	4.00264
Modulus of Subgrade Reaction (Total) [ksf/ft]	-3952.42	988.654
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-148.896	1690.82
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-8117.05	2142.83
Total Strain	0	0.00472358
Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	-1.42109e-14	1.42109e-14
Pre-consolidation Stress [ksf]	0	3.54209
Over-consolidation Ratio	-196.21	1.02324
Void Ratio	-0.0100545	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	-0.00265732	0.0645168

Stage: 50 Years Post Construction

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.96203
Total Consolidation Settlement [in]	0	0.851145
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0.851145
Immediate Settlement [in]	0	1.11089
Loading Stress ZZ [ksf]	0	4.00852
Loading Stress XX [ksf]	-0.206463	3.96986
Loading Stress YY [ksf]	-0.234475	4.00264
Effective Stress ZZ [ksf]	0	4.00852
Effective Stress XX [ksf]	-0.206463	3.96986
Effective Stress YY [ksf]	-0.234475	4.00264
Total Stress ZZ [ksf]	0	4.00852
Total Stress XX [ksf]	-0.206463	3.96986
Total Stress YY [ksf]	-0.234475	4.00264
Modulus of Subgrade Reaction (Total) [ksf/ft]	-3952.42	988.654
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	-148.896	1690.82
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	-8117.05	2142.83
Total Strain	0	0.00472358
Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	-1.42109e-14	1.42109e-14
Pre-consolidation Stress [ksf]	0	3.54209
Over-consolidation Ratio	-196.21	1.02324
Void Ratio	-0.0100545	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	-0.00265732	0.0645168

Loads

1. Polygonal Load: "Pump Station"

Label	Pump Station
Load Type	Flexible
Area of Load	3195.38 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-2.04	17
Construction	-1.04	17
50 Years Post Construction	-1.04	17

Coordinates

X [ft]	Y [ft]
111.976	-277.24
143.976	-277.24
148.465	-217.907
143.976	-217.775
143.976	-187.24
150.785	-187.24
151.138	-182.574
111.976	-182.574

2. Polygonal Load: "Polygonal Load 5"

Label	Polygonal Load 5
Load Type	Flexible
Area of Load	300.664 ft2
Load	4 ksf
Depth	2.5 ft
Installation Stage	Construction

Coordinates

X [ft]	Y [ft]
108	-5.78125
108	-7.781
146.297	-7.781
140.263	-83.5521
108	-83.5521
108	-85.5521
142.263	-85.5521
147.87	-11.428
148.297	-5.78125

3. Polygonal Load: "Polygonal Load 7"

Label	Polygonal Load 7
Load Type	Flexible
Area of Load	10674.8 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	-0.21	14
50 Years Post Construction	-0.21	14

Coordinates

X [ft]	Y [ft]
25.7962	-153.333
25.7962	-158.635
66.9004	-158.635
66.9004	-153.333
108	-153.333
108	-33.083
21.041	-33.083
21.041	-153.333

4. Polygonal Load: "Polygonal Load 8"

Label	Polygonal Load 8
Load Type	Flexible
Area of Load	4353.84 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	0.66	14
50 Years Post Construction	0.66	14

Coordinates

X [ft]	Y [ft]
-15.3333	-33.083
-15.3333	-136.667
-13.6667	-136.667
-13.6354	-148.667
-15.3333	-148.667
-15.3333	-153.333
21.041	-153.333
21.041	-33.083

5. Polygonal Load: "Polygonal Load 6"

Label	Polygonal Load 6
Load Type	Flexible
Area of Load	482.944 ft2
Load	4 ksf
Depth	2.5 ft
Installation Stage	Construction

Coordinates

X [ft]	Y [ft]
0	-33.0701
2	-33.083
2	-3.69792
106	-3.69792
106	-33.083
108	-33.083
108	-7.781
108	-5.78125
108	0
104.365	0
104.365	-1.69792
96.3646	-1.69792
96.3646	0
17.3333	0
17.3333	-1.69792
5.33333	-1.69792
5.33333	0
0	0

6. Polygonal Load: "Polygonal Load 3"

Label	Polygonal Load 3
Load Type	Flexible
Area of Load	391.436 ft2
Load	4 ksf
Depth	2.5 ft
Installation Stage	Construction

Coordinates

X [ft]	Y [ft]
111.983	-181.282
156.096	-181.29
147.455	-278.5
111.942	-278.5
111.942	-280.5
149.81	-280.5
158.326	-179.282
111.983	-179.282

7. Rectangular Load: "Rectangular Load 4"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-0.773	-206.783
8.227	-206.783
8.227	-197.783
-0.773	-197.783

8. Rectangular Load: "Rectangular Load 9"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
20.227	-206.783
29.227	-206.783
29.227	-197.783
20.227	-197.783

9. Rectangular Load: "Rectangular Load 10"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
63.227	-206.783
72.227	-206.783
72.227	-197.783
63.227	-197.783

10. Rectangular Load: "Rectangular Load 11"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
84.227	-206.783
93.227	-206.783
93.227	-197.783
84.227	-197.783

11. Rectangular Load: "Rectangular Load 12"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-0.773	-224.783
8.227	-224.783
8.227	-215.783
-0.773	-215.783

12. Rectangular Load: "Rectangular Load 13"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-0.773	-242.783
8.227	-242.783
8.227	-233.783
-0.773	-233.783

13. Rectangular Load: "Rectangular Load 14"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-0.773	-260.783
8.227	-260.783
8.227	-251.783
-0.773	-251.783

14. Rectangular Load: "Rectangular Load 15"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
20.227	-224.783
29.227	-224.783
29.227	-215.783
20.227	-215.783

15. Rectangular Load: "Rectangular Load 16"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
20.227	-242.783
29.227	-242.783
29.227	-233.783
20.227	-233.783

16. Rectangular Load: "Rectangular Load 17"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
20.227	-260.783
29.227	-260.783
29.227	-251.783
20.227	-251.783

17. Rectangular Load: "Rectangular Load 18"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
63.227	-224.783
72.227	-224.783
72.227	-215.783
63.227	-215.783

18. Rectangular Load: "Rectangular Load 19"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
63.227	-242.783
72.227	-242.783
72.227	-233.783
63.227	-233.783

19. Rectangular Load: "Rectangular Load 20"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
63.227	-260.783
72.227	-260.783
72.227	-251.783
63.227	-251.783

20. Rectangular Load: "Rectangular Load 21"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
84.227	-224.783
93.227	-224.783
93.227	-215.783
84.227	-215.783

21. Rectangular Load: "Rectangular Load 22"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
84.227	-242.783
93.227	-242.783
93.227	-233.783
84.227	-233.783

22. Rectangular Load: "Rectangular Load 23"

Length	9 ft
Width	9 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	81 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
84.227	-260.783
93.227	-260.783
93.227	-251.783
84.227	-251.783

23. Rectangular Load: "Rectangular Load 24"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
44.879	-203.995
48.879	-203.995
48.879	-199.995
44.879	-199.995

24. Rectangular Load: "Rectangular Load 25"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
45.205	-221.769
49.205	-221.769
49.205	-217.769
45.205	-217.769

25. Rectangular Load: "Rectangular Load 26"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
45.548	-240.049
49.548	-240.049
49.548	-236.049
45.548	-236.049

26. Rectangular Load: "Rectangular Load 27"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
45.385	-257.986
49.385	-257.986
49.385	-253.986
45.385	-253.986

27. Rectangular Load: "Rectangular Load 28"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
103.476	-203.123
107.476	-203.123
107.476	-199.123
103.476	-199.123

28. Rectangular Load: "Rectangular Load 29"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
103.476	-222.873
107.476	-222.873
107.476	-218.873
103.476	-218.873

29. Rectangular Load: "Rectangular Load 30"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
103.476	-240.085
107.476	-240.085
107.476	-236.085
103.476	-236.085

30. Rectangular Load: "Rectangular Load 31"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
103.476	-258.385
107.476	-258.385
107.476	-254.385
103.476	-254.385

31. Rectangular Load: "Rectangular Load 32"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-19.514	-203.532
-15.514	-203.532
-15.514	-199.532
-19.514	-199.532

32. Rectangular Load: "Rectangular Load 33"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-19.52	-222.188
-15.52	-222.188
-15.52	-218.188
-19.52	-218.188

33. Rectangular Load: "Rectangular Load 34"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft2
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-19.52	-238.857
-15.52	-238.857
-15.52	-234.857
-19.52	-234.857

34. Rectangular Load: "Rectangular Load 35"

Length	4 ft
Width	4 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	16 ft ²
Load	1 ksf

Advanced Staging

Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-1.68	14
Construction	2.32	14
50 Years Post Construction	2.32	14

Coordinates

X [ft]	Y [ft]
-19.702	-258.243
-15.702	-258.243
-15.702	-254.243
-19.702	-254.243

35. Rectangular Load: "Rectangular Load 1"

Length	14 ft
Width	10 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	140 ft ²
Load	1 ksf

Advanced Staging

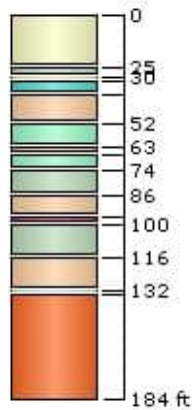
Stage	Load Factor	Depth [ft]
Existing Condition	0	0
Excavation	-0.96	8
Construction	0.04	8
50 Years Post Construction	0.04	8

Coordinates








X [ft]	Y [ft]
-52.721	-277.796
-38.721	-277.796
-38.721	-267.796
-52.721	-267.796

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Gravel_Cobbles	25	0
2	Sand	5	25
3	Sandy Silt	2	30
4	Clay OCR = 1.75	6	32
5	Sandy Silt	14	38
6	Clay OCR = 1.7	11	52
7	Sandy Silt	4	63
8	Clay OCR = 1.7	7	67
9	Sand	12	74
10	Sandy Silt	10	86
11	Clay OCR=1.05	4	96
12	Sand	16	100
13	Sandy Silt	16	116
14	Sand	2	132
15	Deep Soils (Sand and Silt)	50	134



Soil Properties

Property	Gravel_Cobbles	Sand	Sandy Silt	Clay OCR = 1.75
Color				
Unit Weight [kips/ft3]	0.12	0.12	0.115	0.122
Saturated Unit Weight [kips/ft3]	0.13	0.12	0.115	0.122
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Disabled
Es [ksf]	2800	2000	1000	-
Esur [ksf]	2800	2000	1000	-
Primary Consolidation	Disabled	Disabled	Disabled	Enabled
Material Type				Non-Linear
Cce	-	-	-	0.11
Cre	-	-	-	0.012
e0	-	-	-	1.1
OCR	-	-	-	1.75
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1
Property	Clay OCR = 1.7	Clay OCR=1.05	Deep Soils (Sand and Silt)	
Color				
Unit Weight [kips/ft3]	0.122	0.12	0.12	
Saturated Unit Weight [kips/ft3]	0.122	0.12	0.12	
K0	1	1	1	
Immediate Settlement	Disabled	Disabled	Enabled	
Es [ksf]	-	-	2000	
Esur [ksf]	-	-	2000	
Primary Consolidation	Enabled	Enabled	Disabled	
Material Type	Non-Linear	Non-Linear		
Cce	0.16	0.15	-	
Cre	0.016	0.018	-	
e0	1.1	1.1	-	
OCR	1.7	1.05	-	
Undrained Su A [kips/ft2]	0	0	0	
Undrained Su S	0.2	0.2	0.2	
Undrained Su m	0.8	0.8	0.8	
Piezo Line ID	1	1	1	

Groundwater

Groundwater method

Piezometric Lines

Water Unit Weight

0.0624 kips/ft³

Piezometric Line Entities

ID	Depth (ft)
1	15 ft

Query

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	46.879, -201.995	Auto: 115
2	Query Point 2	88.727, -202.283	Auto: 115
3	Query Point 3	105.476, -220.873	Auto: 115
4	Query Point 4	3.727, -202.283	Auto: 115
5	Query Point 5	63.904, -91.956	Auto: 115
6	Query Point 6	96.398, -43.936	Auto: 115
7	Query Point 7	1.757, -2.049	Auto: 115
8	Query Point 8	11.894, -143.352	Auto: 115
9	Query Point 9	94.588, -142.278	Auto: 115
10	Query Point 10	128.839, -230.119	Auto: 115
11	Query Point 11	119.234, -191.138	Auto: 115
12	Query Point 12	137.023, -269.737	Auto: 115
13	Query Point 13	56.862, -1.92	Auto: 115
14	Query Point 14	3.943, -92.199	Auto: 115
15	Query Point 15	106.942, -6.893	Auto: 115
16	Query Point 16	144.086, -47.453	Auto: 115
17	Query Point 17	120.369, -84.735	Auto: 115
18	Query Point 18	-7.408, -42.429	Auto: 115
19	Query Point 19	35.368, -141.664	Auto: 115
20	Query Point 20	30.397, -43.107	Auto: 115
21	Query Point 21	0.969, -28.124	Auto: 115
22	Query Point 22	121.243, -180.253	Auto: 115
23	Query Point 23	156.955, -183.933	Auto: 115
24	Query Point 24	114.687, -279.53	Auto: 115
25	Query Point 25	148.504, -279.358	Auto: 115
26	Query Point 26	153.688, -220.39	Auto: 115
27	Query Point 27	150.155, -261.098	Auto: 115
28	Query Point 28	105.476, -201.123	Auto: 115
29	Query Point 29	24.727, -202.283	Auto: 115
30	Query Point 30	67.727, -202.283	Auto: 115
31	Query Point 31	-17.514, -201.532	Auto: 115
32	Query Point 32	-17.52, -220.188	Auto: 115
33	Query Point 33	3.727, -220.283	Auto: 115
34	Query Point 34	24.727, -220.283	Auto: 115
35	Query Point 35	47.205, -219.769	Auto: 115
36	Query Point 36	67.727, -220.283	Auto: 115
37	Query Point 37	88.727, -220.283	Auto: 115
38	Query Point 38	105.476, -238.085	Auto: 115
39	Query Point 39	105.476, -256.385	Auto: 115
40	Query Point 40	88.727, -238.283	Auto: 115
41	Query Point 41	88.727, -256.283	Auto: 115
42	Query Point 42	67.727, -238.283	Auto: 115
43	Query Point 43	67.727, -256.283	Auto: 115
44	Query Point 44	47.548, -238.049	Auto: 115
45	Query Point 45	47.385, -255.986	Auto: 115

46	Query Point 46	24.727, -238.283	Auto: 115
47	Query Point 47	24.727, -256.283	Auto: 115
48	Query Point 48	3.727, -238.283	Auto: 115
49	Query Point 49	3.727, -256.283	Auto: 115
50	Query Point 50	-17.52, -236.857	Auto: 115
51	Query Point 51	-17.702, -256.243	Auto: 115
52	Query Point 52	-45.721, -272.796	Auto: 115
53	Query Point 53	-40.333, -268.968	Auto: 115
54	Query Point 54	-51.77, -276.707	Auto: 115

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Tanks

ϕ_f	32.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	9.00	ft
L	9.00	ft
D_f	14.00	ft
θ		deg
V		kip
H		kip

q_n 84.8 ksf

N_{cm} 58.7

N_c 35.5
 s_c 1.653521
 i_c 1

N_{qm} 47.33064

N_q 23.2
 s_q 1.624869
 d_q 1.255556
 i_q 1

$N_{\gamma m}$ 18.12

N_γ 30.2
 s_γ 0.6
 i_γ 1

q_n 84.77027 ksf

C_{wq} 1
 $C_{w\gamma}$ 0.537037

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

- c = cohesion, taken as undrained shear strength (ksf)
- N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
- N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
- N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)
- γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)
- D_f = footing embedment depth (ft)
- B = footing width (ft)
- $C_{wq}, C_{w\gamma}$ = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)
- s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)
- d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)
- i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \Phi_b q_n \quad (10.6.3.1.1-1)$$

where:

Φ_b = resistance factor specified in Article 10.5.5.2.2
 q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (mH/cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L/B)/(1 + L/B)] \cos^2 \theta + [(2 + B/L)/(1 + B/L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Water Treatment Plant

ϕ_f	34.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	120.00	ft
L	120.00	ft
D_f	14.00	ft
θ		deg
V		kip
H		kip

q_n 172 ksf

N_{cm} 71.6

N_c 42.2

s_c 1.696682

i_c 1

N_{qm} 49.23055

N_q 29.4

s_q 1.674509

d_q 1

i_q 1

$N_{\gamma m}$ 24.66

N_γ 41.1

s_γ 0.6

i_γ 1

q_n 171.9765 ksf

C_{wq} 1

C_{wy} 0.502778

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{wy} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

C_{wq}, C_{wy} = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \Phi_b q_n \quad (10.6.3.1.1-1)$$

where:

Φ_b = resistance factor specified in Article 10.5.5.2.2

q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (nH / cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q) / (N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L / B) / (1 + L / B)] \cos^2 \theta + [(2 + B / L) / (1 + B / L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Pump Station

ϕ_f	34.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	35.00	ft
L	95.00	ft
D_f	17.00	ft
θ		deg
V		kip
H		kip

q_n 107.3 ksf

N_{cm} 53.03158

N_c 42.2

s_c 1.256672

i_c 1

N_{qm} 36.70599

N_q 29.4

s_q 1.248503

d_q 1

i_q 1

N_{ym} 35.04316

N_γ 41.1

s_γ 0.852632

i_γ 1

q_n 107.2708 ksf

C_{wq} 0.941176

C_{wy} 0.5

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{ym} C_{wy} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{ym} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

C_{wq}, C_{wy} = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \Phi_b q_n \quad (10.6.3.1.1-1)$$

where:

Φ_b = resistance factor specified in Article 10.5.5.2.2
 q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (mH/cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L/B)/(1 + L/B)] \cos^2 \theta + [(2 + B/L)/(1 + B/L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Diversion Box

ϕ_f	34.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	10.00	ft
L	14.00	ft
D_f	8.00	ft
θ		deg
V		kip
H		kip

q_n 54.7 ksf

N_{cm} 63.2

N_c 42.2

s_c 1.49763

i_c 1

N_{qm} 43.56468

N_q 29.4

s_q 1.481792

d_q 1

i_q 1

$N_{\gamma m}$ 29.35714

N_γ 41.1

s_γ 0.714286

i_γ 1

q_n 54.73923 ksf

C_{wq} 1

$C_{w\gamma}$ 0.733333

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

$C_{wq}, C_{w\gamma}$ = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \Phi_b q_n \quad (10.6.3.1.1-1)$$

where:

Φ_b = resistance factor specified in Article 10.5.5.2.2
 q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (nH / cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q) / (N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L / B) / (1 + L / B)] \cos^2 \theta + [(2 + B / L) / (1 + B / L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Valve Vault

ϕ_f	34.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	17.00	ft
L	17.00	ft
D_f	8.00	ft
θ		deg
V		kip
H		kip

q_n 63.3 ksf

N_{cm} 71.6

N_c 42.2

s_c 1.696682

i_c 1

N_{qm} 49.23055

N_q 29.4

s_q 1.674509

d_q 1

i_q 1

N_{ym} 24.66

N_γ 41.1

s_γ 0.6

i_γ 1

q_n 63.29033 ksf

C_{wq} 1

C_{wy} 0.637255

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{ym} C_{wy} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{ym} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

C_{wq}, C_{wy} = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \phi_b q_n \quad (10.6.3.1.1-1)$$

where:

ϕ_b = resistance factor specified in Article 10.5.5.2.2

q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (mH/cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L/B)/(1 + L/B)] \cos^2 \theta + [(2 + B/L)/(1 + B/L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

where:

B = footing width (ft)

L = footing length (ft)

H = unfactored horizontal load (kips)

V = unfactored vertical load (kips)

In practice, therefore, for footings with modest embedment, consideration may be given to omission of the load inclination factors.

Figure C10.6.3.1.2a-1 shows the convention for determining the θ angle in Eq. 10.6.3.1.2a-9.

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Strip Footings

ϕ_f	34.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	2.00	ft
L	100.00	ft
D_f	2.50	ft
θ		deg
V		kip
H		kip

q_n 15.8 ksf

N_{cm} 42.788

N_c 42.2
 s_c 1.013934
 i_c 1

N_{qm} 36.35187

N_q 29.4
 s_q 1.01349
 d_q 1.22
 i_q 1

$N_{\gamma m}$ 40.7712

N_γ 41.1
 s_γ 0.992
 i_γ 1

q_n 15.7981 ksf

C_{wq} 1
 $C_{w\gamma}$ 1

where:

B = footing width (ft)
 L = footing length (ft)
 H = unfactored horizontal load (kips)

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

$C_{wq}, C_{w\gamma}$ = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \phi_b q_n \quad (10.6.3.1.1-1)$$

where:

ϕ_b = resistance factor specified in Article 10.5.5.2.2
 q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (mH/cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L/B)/(1 + L/B)] \cos^2 \theta + [(2 + B/L)/(1 + B/L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

In practice, therefore, for footings with modest embedment, consideration may be given to omission of the load inclination factors.

Figure C10.6.3.1.2a-1 shows the convention for determining the θ angle in Eq. 10.6.3.1.2a-9

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2

AASHTO (2017) Bearing Resistance of Soil - Provo WTP Spread Footings

ϕ_f	34.0	deg
c	0	psf
γ	120.0	pcf
D_w	15.0	ft
B	4.00	ft
L	4.00	ft
D_f	2.50	ft
θ		deg
V		kip
H		kip

q_n 20.7 ksf

N_{cm} 71.6

N_c 42.2
 s_c 1.696682
 i_c 1

N_{qm} 49.23055

N_q 29.4
 s_q 1.674509
 d_q 1
 i_q 1

$N_{\gamma m}$ 24.66

N_γ 41.1
 s_γ 0.6
 i_γ 1

q_n 20.68757 ksf

C_{wq} 1
 $C_{w\gamma}$ 1

where:

B = footing width (ft)
 L = footing length (ft)
 H = unfactored horizontal load (kips)

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma} \quad (10.6.3.1.2a-1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a-2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a-3)$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a-4)$$

where:

c = cohesion, taken as undrained shear strength (ksf)

N_c = cohesion term (undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_q = surcharge (embedment) term (drained or undrained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

N_γ = unit weight (footing width) term (drained loading) bearing capacity factor as specified in Table 10.6.3.1.2a-1 (dim)

γ = total (moist) unit weight of soil above or below the bearing depth of the footing (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

$C_{wq}, C_{w\gamma}$ = correction factors to account for the location of the groundwater table as specified in Table 10.6.3.1.2a-2 (dim)

s_c, s_γ, s_q = footing shape correction factors as specified in Table 10.6.3.1.2a-3 (dim)

d_q = correction factor to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation as specified in Table 10.6.3.1.2a-4 (dim)

i_c, i_γ, i_q = load inclination factors determined from Eqs. 10.6.3.1.2a-5 or 10.6.3.1.2a-6, and 10.6.3.1.2a-7 and 10.6.3.1.2a-8 (dim)

$$q_R = \phi_b q_n \quad (10.6.3.1.1-1)$$

where:

ϕ_b = resistance factor specified in Article 10.5.5.2.2
 q_n = nominal bearing resistance (ksf)

For $\phi_f = 0$:

$$i_c = 1 - (mH/cBLN_c) \quad (10.6.3.1.2a-5)$$

For $\phi_f > 0$:

$$i_c = i_q - [(1 - i_q)/(N_q - 1)] \quad (10.6.3.1.2a-6)$$

in which:

$$i_q = \left[1 - \frac{H}{(V + cBL \cot \phi_f)} \right]^n \quad (10.6.3.1.2a-7)$$

$$i_\gamma = \left[1 - \frac{H}{V + cBL \cot \phi_f} \right]^{(n+1)} \quad (10.6.3.1.2a-8)$$

$$n = [(2 + L/B)/(1 + L/B)] \cos^2 \theta + [(2 + B/L)/(1 + B/L)] \sin^2 \theta \quad (10.6.3.1.2a-9)$$

In practice, therefore, for footings with modest embedment, consideration may be given to omission of the load inclination factors.

Figure C10.6.3.1.2a-1 shows the convention for determining the θ angle in Eq. 10.6.3.1.2a-9

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2

Appendix G Lateral Earth Pressure Analysis Results

Lateral Earth Pressure

Client
Project name
Project Number
Date

Hansen Allen And Luce, Inc
Provo WTP - WTP Site (granular or fine-grained)
60670884
9/19/2022

Wall Design Parameters

Total Unit Weight of Soil for Active and At-Rest Calculations, γ (pcf)
Total Unit Weight of Soil for Passive Calculations, γ (pcf)
Friction Angle of Soil, ϕ' ($^{\circ}$)
Soil-Wall Interface Friction Angle from Normal, δ' ($^{\circ}$)
Slope of Backfill from Horizontal, α ($^{\circ}$)
Backslope of Wall from Vertical, θ ($^{\circ}$)
Free Field PGA
Horizontal Seismic Coefficient, K_h
Vertical Seismic Coefficient, K_v

135
115
28
14.0
0
0
0.63
0.3465
0

At-Rest

Total Unit Weight of Soil, γ (pcf)
Friction Angle of Soil, ϕ' ($^{\circ}$)
Over Consolidation Ration (OCR)
At-Rest Earth Pressure Coefficient, K_0
At-Rest Equivalent Fluid Density, γ_e (pcf)
Submerged At-Rest Equivalent Fluid Density, $\gamma_{e(sub)}$ (pcf)

Mayne and Kulhawy (1982)

135
28
1.0
0.53
71.6
38.5

Reference: Mayne & Kulhawy (1982) from
Das, B. M. and Sobhan, K. (2014). Principles of Geotechnical
Engineering. Cengage Learning, Stamford, CT. p. 494-495

$$K_0 = (1 - \sin \phi)(OCR)^{\sin \phi}$$
$$\gamma_e = \gamma_m K_0 \qquad \gamma_{e(sub)} = (\gamma - \gamma_{water}) K_0$$

At-Rest Seismic

Free Field PGA
Total Unit Weight of Soil, γ (pcf)
Dynamic Component of At-Rest Seismic Earth Pressure Coefficient, ΔK_{0e}
Total Seismic At-Rest Earth Pressure Coefficient, K_{0e}
Total At-Rest Seismic Equivalent Fluid Density, γ_e (pcf)
Dynamic Component of At-Rest Seismic Equivalent Fluid Density, $\Delta \gamma_e$ (pcf)
Submerged Dynamic Component of At-Rest Seismic Equivalent Fluid Density, $\Delta \gamma_{e(sub)}$ (pcf)

Mikola & Sitar (2013)

0.63
135
0.42
0.95
128.3
56.7
30.5

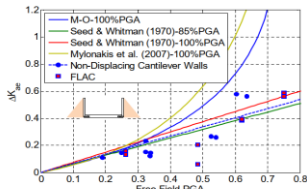


Figure 6.18. Dynamic earth pressure coefficient as a function of PGA for non-displacing U-shaped cantilever walls with medium dense sand backfill.

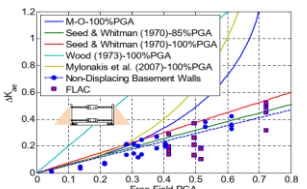


Figure 6.16. Dynamic earth pressure coefficient as a function of PGA for non-displacing basement structures with medium dense sand backfill.

$$\gamma_e = \gamma_m K_{0e} \qquad \Delta \gamma_e = \gamma_m \Delta K_{0e}$$

Active

Total Unit Weight of Soil, γ (pcf)
Friction Angle of Soil, ϕ' ($^{\circ}$)
Soil-Wall Interface Friction Angle from Normal, δ' ($^{\circ}$)
Slope of Backfill from Horizontal, α ($^{\circ}$)
Backslope of Wall from Vertical, θ ($^{\circ}$)
Active Earth Pressure Coefficient, K_a
Active Equivalent Fluid Density, γ_e (pcf)
Submerged Active Equivalent Fluid Density, $\gamma_{e(sub)}$ (pcf)

Coulomb (1776)

135
28
14
0
0
0.33
44.1
23.7

Reference: Coulomb (1776) from
Das, B. M. and Sobhan, K. (2014). Principles of Geotechnical Engineering.
Cengage Learning, Stamford, CT. p. 518-519; See Figure 13.19 p. 518.

$$K_a = \frac{\cos^2(\varphi' - \theta)}{\cos^2 \theta \cos(\delta' + \theta) \left[1 + \frac{\sin(\delta' + \varphi') \sin(\varphi' - \alpha)}{\cos(\delta' + \theta) \cos(\theta - \alpha)} \right]^2}$$

$$\gamma_e = \gamma_m K_a \qquad \gamma_{e(sub)} = (\gamma - \gamma_{water}) K_a$$

Active Seismic

Total Unit Weight of Soil, γ (pcf)	135
Friction Angle of Soil, ϕ' (°)	28
Soil-Wall Interface Friction Angle from Normal, δ' (°)	14
Slope of Backfill from Horizontal, β (°)	0
Backslope of Wall from Vertical, θ (°)	0
Horizontal Seismic Coefficient, K_h	0.35
Vertical Seismic Coefficient, K_v	0.0
Seismic Inertia Angle, Ψ (°)	19.11
Static Active Lateral Earth Pressure Coefficient, K_a	0.33
Total Seismic Active Earth Pressure Coefficient, K_{ae}	0.675
Dynamic Component of K_{ae} , ΔK_{ae}	0.349
Total Active Seismic Equivalent Fluid Density, γ_e (pcf)	91.2
Dynamic Component of Active Seismic Equivalent Fluid Density, $\Delta\gamma_e$ (pcf)	47.1
Submerged Dynamic Component of Active Seismic Equivalent Fluid Density, $\Delta\gamma_{e(sub)}$ (pcf)	25.3

Mononobe-Okabe

Reference: Okabe (1926) & Mononobe and Matsuo (1929) from Kramer, S. L. (1996). Geotechnical Earthquake Engineering. Prentice Hall, Upper Saddle River, NJ. p. 478-480

$$\psi = \tan^{-1} \frac{K_h}{1 - K_v}$$

$$K_{ae} = \frac{\cos^2(\varphi - \psi - \theta)}{\cos\psi \cos^2\theta \cos(\psi + \theta + \delta) \left[1 + \sqrt{\frac{\sin(\varphi + \delta) \sin(\varphi - \psi - \beta)}{\cos(\beta - \theta) \cos(\psi + \theta + \delta)}} \right]^2}$$

$$\Delta K_{ae} = K_{ae} - K_a$$

$$\gamma_e = \gamma_m K_{ae} \quad \Delta\gamma_e = \gamma_m \Delta K_{ae}$$

Passive

Total Unit Weight of Soil, γ (pcf)	115
Friction Angle of Soil, ϕ' (°)	28
Soil-Wall Interface Friction Angle from Normal, δ' (°)	14
Slope of Backfill from Horizontal, β (°)	0
Backslope of Wall from Horizontal, θ (°)	90
$-\delta/\phi'_i$ ratio	-0.500
β/ϕ'_i ratio	0.000
Passive Earth Pressure Coefficient from Chart, $K_{p-Chart}$	5.566
Reduction Factor, R_f	0.771
Passive Earth Pressure Coefficient, K_p	4.291
Skew Angle of Wall from Normal, θ_{skew} (°)	0.0
Reduction Factor for Skew Effects, R_{skew}	1.000
Passive Earth Pressure Coefficient with Skew Effects, $K_{p-skewed}$	4.291
Passive Equivalent Fluid Density, γ_e (pcf)	493.4
Submerged Passive Equivalent Fluid Density, $\gamma_{e(sub)}$ (pcf)	225.7

Log-Spiral

References:

1. U.S Department of the Navy (1982) from American Association of State Highway and Transportation Officials [AASHTO]. (2017). AASHTO LRFD Bridge Design Specifications, U.S. Customary Units. Washington, D.C. Section 3.11.5.4 p. 3-117 to p. 3-118
2. Rollins, K. M., and Jessee, S. J. (2013). "Passive Force-Deflection Curves for Skewed Abutments." Journal of Bridge Engineering, 18(10), 1086–1094.

$$R_{skew} = (7.79 * 10^{-5}) \theta_{skew}^2 - 0.018 \theta_{skew} + 1$$

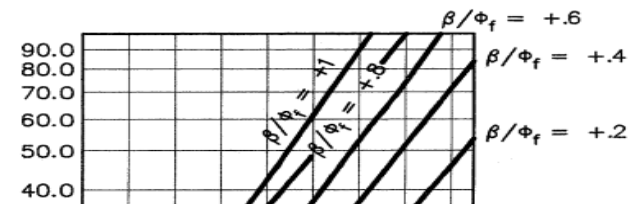
$$K_{pskewed} = R_{skew} K_p$$

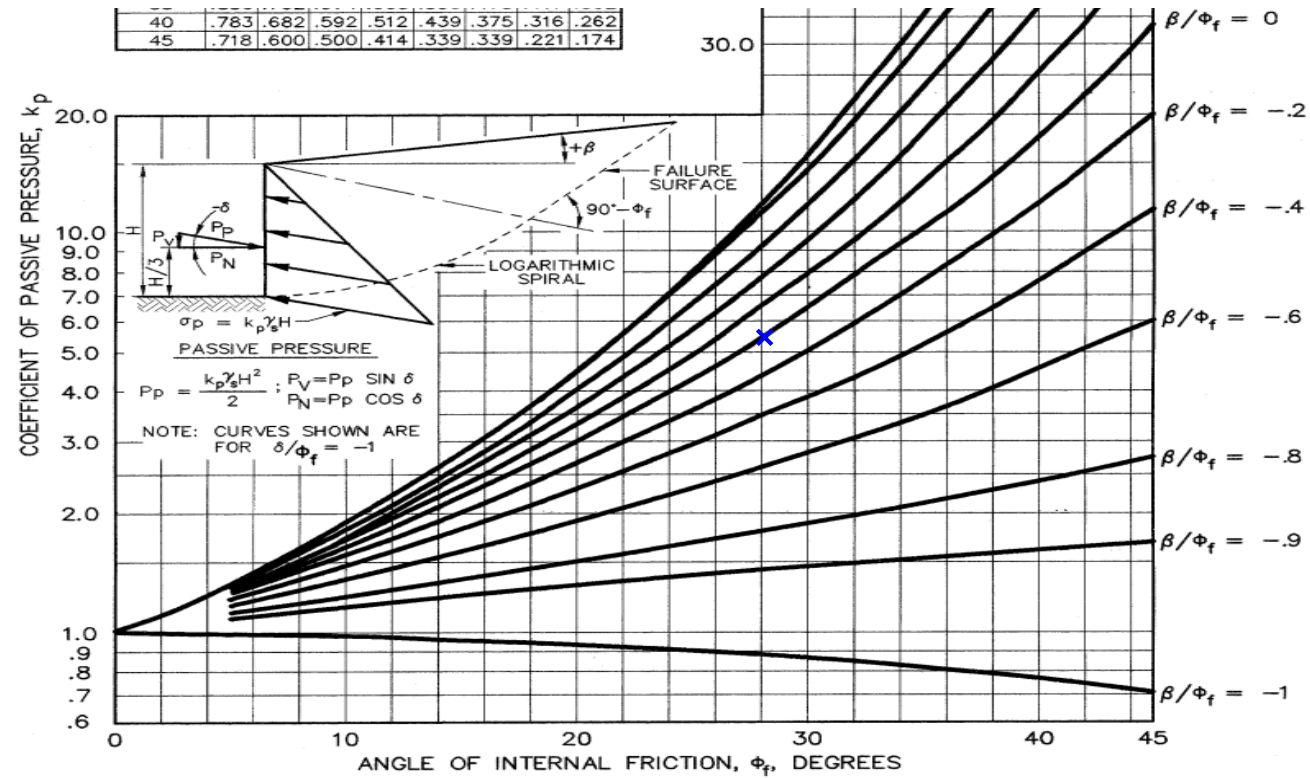
$$\gamma_e = \gamma_m K_p$$

$$\gamma_{e(sub)} = (\gamma - \gamma_{water}) K_p$$

Graphical Solution for Log-Spiral Passive Earth Pressure Coefficient:

REDUCTION FACTOR (R) OF k_p FOR VARIOUS RATIOS OF $-\delta/\phi_f$								
$\phi_f \backslash \delta/\phi_f$	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
10	.978	.962	.946	.929	.912	.898	.881	.864
15	.961	.934	.907	.881	.854	.830	.803	.775
20	.939	.901	.862	.824	.787	.752	.716	.678
25	.912	.860	.808	.759	.711	.666	.620	.574
30	.878	.811	.746	.686	.627	.574	.520	.467
35	.836	.752	.674	.603	.536	.475	.417	.362





Passive Seismic

Total Unit Weight of Soil, γ (pcf)	115
Effective Horizontal Acceleration, K_h (g)	0.35
Friction Angle of Soil, ϕ_f (°)	28
Soil-Wall Interface Friction Angle from Normal, δ (°)	19
Slope of Backfill from Horizontal, β (°)	0
Skew Angle of Wall from Normal, θ_{skew} (°)	0.0
δ/ϕ_f ratio	0.67
Total Passive Seismic Earth Pressure Coefficient, K_{pe}	3.194
Total Passive Seismic Earth Pressure Coefficient with Skew Effects, $K_{pe-skew}$	3.194
Dynamic Component of K_{pe} , ΔK_{pe}	-1.097
Dynamic Component of K_{pe} with Skew Effects, $\Delta K_{pe-skew}$	-1.097
Total Passive Seismic Equivalent Fluid Density, γ_e (pcf)	367.3
Dynamic Component of Passive Seismic Equivalent Fluid Density, $\Delta \gamma_e$ (pcf)	-126.1
Submerged Dynamic Component of Passive Seismic Equivalent Fluid Density, $\Delta \gamma_{e(sub)}$ (pcf)	-57.7

Log-spiral & Anderson et al. (2008)

115
0.35
28
19
0
0.0
0.67
3.194
3.194
-1.097
-1.097
367.3
-126.1
-57.7

$$K_{pe-skewed} = R_{skew} K_{pe}$$

$$\Delta K_{pe} = K_{pe} - K_p$$

$$\gamma_e = \gamma_m K_{pe} \quad \Delta \gamma_e = \gamma_m \Delta K_{pe}$$

(Skew effects included in results if applicable)

(Skew effects included in results if applicable)

References:

- Anderson et al. (2008) and U.S Department of the Navy (1982) from American Association of State Highway and Transportation Officials [AASHTO]. (2017). AASHTO LRFD Bridge Design Specifications, U.S. Customary Units. Washington, D.C. Section A11.4 p. 11-115 to p. 11-119
- Rollins, K. M., and Jessee, S. J. (2013). "Passive Force-Deflection Curves for Skewed Abutments." Journal of Bridge Engineering, 18(10), 1086-1094.

Graphical Solution for Log-Spiral Passive Seismic Earth
Pressure Coefficient:

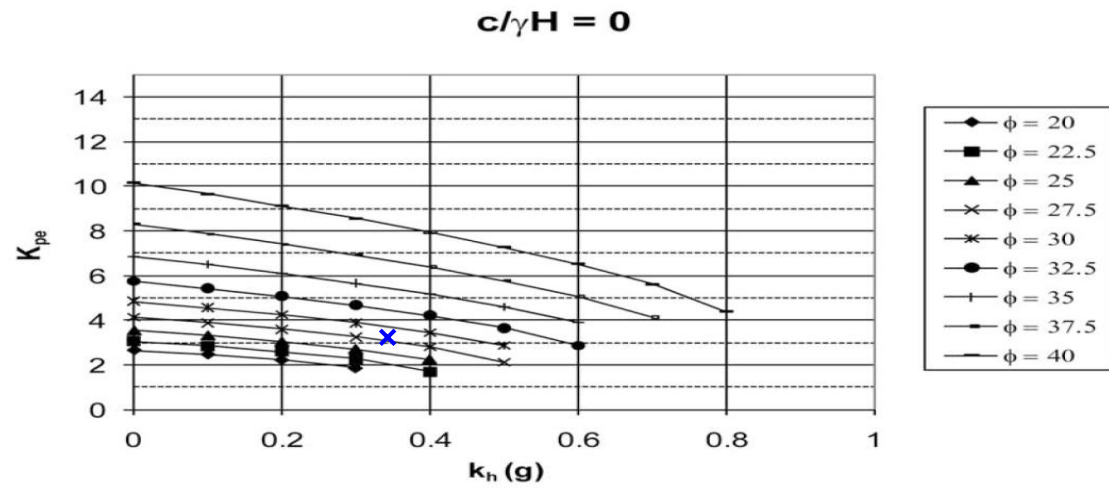


Figure A11.4-2—Seismic Passive Earth Pressure Coefficient Based on Log Spiral Procedure for $c/\gamma H = 0$ and 0.05 (c = soil cohesion, γ = soil unit weight, and H = height or depth of wall over which the passive resistance acts)

Note: $k_h = A_s = k_{h0}$ for wall heights greater than 20 ft.

Bryan W. Franke, P.E.
Senior Project Geotechnical Engineer
T: 801.904.4047
M: 801.696.4964
E: bryan.franke@aecom.com

AECOM
756 East Winchester Street
Suite 400
Salt Lake City, UT 84107
aecom.com